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DIAGNOSIS

EIGHTH SYMPOSIUM

NEURORADIOLOGICUM

PARIS

25—30 September 1967

Technique — Skull examinations — Pneumography

Angiography — Radioisotopes

Ultrasound and Thermography

Spine including Angiography and Myelography

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Examples

BOIJSEN E and DAHN I Selective angiography of bronchial and intercostal arteries Acta radiol Diagnosis 3 (1965) 513

KEITH A Human embryology and morphology 6th edition, p 523 Arnold & Co, London 1948

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EIGHTH SYMPOSIUM NEURORADIOLOGICUM

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In this special issue we have the privilege of publishing the majority of papers presented at the Eighth Symposium Neuroradiologicum in Paris. The papers are grouped according to the subject matter and the aspects from which this is treated. Some of the contributions have therefore not been included in the same subject groups as in the Symposium programme. The classification of certain papers, such as those dealing with comparisons between different methods of examination, may be a matter of opinion, but we have endeavoured to place each paper under the heading that seemed most appropriate. In each group, the papers are arranged in alphabetical order according to the first author's name. The titles of the Symposium papers not published here are included in the Table of Contents under the sections in which they appeared in the Symposium programme.

Owing to the large number of papers and the revision which in some cases was found necessary, the preparation of this volume has required a longer time than was originally expected. Financial contributions towards the publication of this special issue have been received from the Organizers of the Eighth Symposium and from Kodak-Pathe S. A., Paris, for which Acta Radiologica is deeply grateful.

The Editor

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COLLOIDAL BARIUM SULFATE AS RADIOGRAPHIC MARKER IN SURGICAL TREATMENT OF CAVITARY BRAIN LESIONS

Report on three years experience

by

JOSEPH H ALLEN and WILLIAM F MEACHAM

Instillation of contrast material into a cavitary brain lesion, particularly an encapsulated abscess or rarely a cystic tumor affords localization of the cavity for subsequent aspiration and indicates the progress of co-aptation of the cavity wall A high proportion of brain abscess cases may be managed in this way

Thorotrast, a trade name for a colloidal preparation of thorium dioxide, has been used extensively for this purpose usually enabling a good demonstration of the cavity wall without detectable immediate reaction (RADOVICI & MELLER 1932 TUTTON & OLLERENSHAW 1938) Unfortunately, these characteristics of Thorotrast after its introduction in 1928 by BLUBAUM et coll, prompted its use in virtually every kind of contrast examination ever devised, and the tragic delayed effects of scarring and neoplasia, both local and systemic, produced by its radioactivity are now generally recognized (LOONEY 1960 BLOMBERG et coll 1963 HORTA et coll 1965)

Numerous reports of Thorotrast toxicity to the central nervous system have appeared These include severe arachnoiditis and myelopathy in the spine and

FROM THE DEPARTMENTS OF RADIOLOGY AND NEUROSURGERY VANDERBILT UNIVERSITY HOSPITAL NASHVILLE TENNESSEE U S A

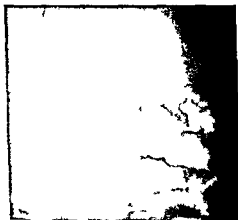


a



b

Fig 2 Films showing maximum (a) and ultimate minimum (b) sizes of the cavity The latter f lm was obtained 8 months after the first one



a



b

Fig 3 An 8 day film interval showing new loculation on the later film

Micropaque powder (approximately 2 ml by measurement) are mixed with sterile water to a total volume of 10 ml producing a consistency similar to a fairly thick cream It is subsequently sterilized in an autoclave and 2 to 5 ml are injected directly through a syringe into the abscess cavity, along with anti biotics in most cases Care is taken to avoid injection of the material into the subarachnoid space



Fig 1 In the film obtained immediately after instillation of the Micropaque suspension (a) the contrast material appears amorphous Four days later (b), the cavity is well outlined after phagocytosis The ultimate appearance 2 1/2 years later is shown in (c)

basal intracranial areas after the use of Thorotrast as contrast medium in myelography and cisternography (MALTBY 1964, DALE & LOVE 1967) and meningioma containing Thorotrast particles following Thorotrast ventriculography (KYLE et coll 1963) Interesting enough, no report of local malignancy induced by deposition of Thorotrast in a cavitary brain lesion could be found, but the reason for discontinuing the use of Thorotrast in these cases seems clear enough

Our experience with the use of Micropaque barium sulfate for the said purpose is described in the present report The first three cases formed the subject of an earlier report (ALLEN & MEACHAM 1966)

Micropaque is a commercial preparation of a powder composed of 92 % barium sulfate, 5 % lactose, and 2 % partially hydrolyzed polysaccharide The micropulverized particles range in size from 0 5 micra to below 0 1 micra, according to the manufacturer (Damancy & Co, Ltd, Ware-Herts England), who also supply the material in liquid form as Steripaque, a sterilized 100 % weight by volume suspension of Micropaque in water As of December 1967, Steripaque had not been released for sale in the United States

In 1962, CLARKE, LANGMAID & WRAY reported favorable experience using Steripaque with eight cases of brain abscess Two further cases using Micropaque were reported in 1964 by ALEXANDER & DAVIS In the 6 month period of maximum follow up, no untoward reaction was reported in either series BLINDERMAN (1964) performed toxicity studies which indicated no significant local reaction in intact brain substance or sterile brain abscesses of cats, but fairly marked cellular reaction following subarachnoid injection A single case of spinal subdural granuloma following instillation of Steripaque into an infected mid occipital subcutaneous dermoid cyst with subdural empyema and a cerebellar hemisphere abscess has been reported (REDDY 1967) This was excised several weeks post instillation with no neurologic sequelae

For our cases, following the suggestion of the manufacturer, 10 grams of



Fig 6 Films showing maximum (a) and ultimate minimum (b) extent of the abscess cavity The latter film was obtained 11 days after the first one

Within 24 to 48 hours after barium phagocytosis by macrophages in the wall is under way good radiographic rendering of the cavity wall is usually achieved (Fig 1)

Air injection produces double contrast and may outline cavitation not shown by barium particularly with poorly encapsulated abscess walls (Fig 5) Within the 3 year period of this study the appearance of the collapsed cavity wall has remained stable after a few weeks following the patient s clinical recovery

Micropaque instillation was used in eight out of ten observed cases of brain abscess Excellent demonstration of the cavity could be achieved in six cases and in two cases it was fairly good

Possible immediate morbidity was encountered in only one case A partially calcified cystic astrocytoma of the right cerebellar hemisphere had been incompletely removed seven and four years previously On the current admission fairly marked signs of meningismus appeared for a 24 hour period following Micropaque instillation later subsiding completely No extravasation into the subarachnoid space could be demonstrated radiographically and the patient s postoperative course was uncomplicated

Seizures have appeared in only one patient a 52 year-old man with a large frontal abscess cavity of unknown origin which yielded anaerobic streptococci This patient had a relatively uncomplicated postoperative course

In only one case has subsequent excision of the abscess cavity wall been per



Fig. 4. Three films showing progressive shrinkage of the cavity wall

a

b

Fig. 5. Upright frontal (a) and lateral decubitus (b) films where air has been used to outline a portion of the abscess cavity



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formed. In this case (Fig. 3), treatment for a poorly encapsulated multiloculated abscess resulted in formation of a cerebral fungus which was ultimately excised.

SUMMARY

Consistently favorable experience with the use of Micropaque barium sulfate suspension for demonstration of the extent of brain cavities would seem to warrant its continued use.

ZUSAMMENFASSUNG

Bei Verwendung einer Micropaque Bariumsulfatsuspension für die Darstellung der Ausbreitung kavernöser Gehirnläsionen hat man so gute Resultate erhalten, dass man die Methode zum fortsetzenden Gebrauch empfehlen wollte.

RÉSUMÉ

Les auteurs ont utilisé avec des résultats toujours favorables une suspension de sulfate de baryum Micropaque pour mettre en évidence l'étendue des lésions cavitaires du cerveau. Ils pensent que cette expérimentation autorise à continuer l'emploi de cette technique.

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PREMIÈRES TENTATIVES D'UTILISATION DE TRÈS HAUTS VOLTAGES EN NEURORADIOLOGIE

par

J BORIES

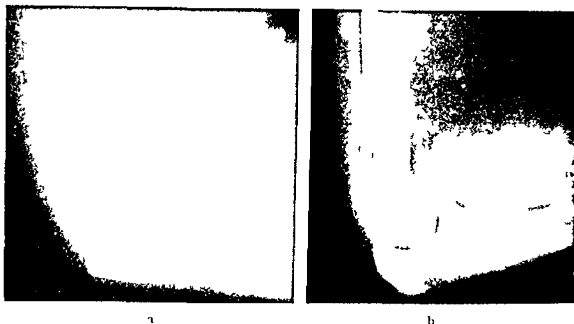
Nous nous interessons depuis longtemps a la radiologie en haute tension

Dans un premier travail (BORIES 1968) nous avons montre que le *comportement* des ecrans fluorescents classiques pour des tensions egalant ou depassant 150 kV etait deplorable et que pour obtenir des images de qualite en haute tension il fallait supprimer la grille antidiffusante et les ecrans fluorescents et travailler avec un film industriel et des ecrans de plomb

Nous ne pouvons ici reprendre le detail de ce travail mais a *titre d exemple* la Fig 1a montre un cliche de coude de profil realise a 150 kV *avec des ecrans fluorescents* haute definition l image est plate et de mauvaise definition Le meme coude de profil a *ete radiographie* a 150 kV egalement, mais sur un film Structurix D7 Agfa Gevaert place entre 2 ecrans de *plomb* de 2/100eme de millimetres d epaisseur (Fig 1b) l image est de tres bonne *qualite* la definition de la structure osseuse excellente et on obtient en meme temps une tres bonne image des *parties molles* Le cliche de face du meme coude (Fig 2) fait dans les memes conditions donne egalement une excellente image de la structure osseuse et on y distingue tres bien les differents plans *musculaires*

Cependant si cette technique nous parait du plus haut interet pour la radiologie des membres nos *premieres tentatives* sur le crane se sont soldees par un echec Cela nous a amene a reprendre nos *experiences sur* la haute tension et a nous interesser aux tres hauts voltages

Il n est pas tres logique en effet de travailler *avec des* ecrans de plomb a des tensions ne depassant pas 130 ou 150 kV La consequence de l absorption par le



a b

Fig 1 Coudes de profil en haute tension avec couple film medical+ecrans fluorescents (a) et avec couple film industriel et ecrans de plomb (b)



Fig 2 Coude de face en haute tension avec couple film industriel+ecrans de plomb

plomb du rayonnement diffuse et des composantes les plus molles du faisceau est une emission d electrons secondaires qui contribuent a impressionner le film et conferent au plomb, si cette emission est suffisante, un effet renforçateur Mais

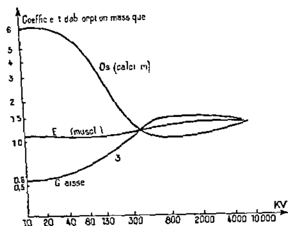


Fig 3 Courbes montrant la variation du coefficient massique d absorption de l os du muscle et de la graisse en fonction de la tension d apres WALTER



Fig 4 a) Radiographie d un rocher (sur crane sec) en incidence axiale a 300 kV b) Rocher en incidence de STENVERS a 300 kV

cet effet renforçateur augmente avec la tension pour atteindre une valeur de 3 a 6 pour des tensions atteignant ou depassant 300 kV

Probleme du contraste Une question capitale se pose en ce qui concerne le contraste qui est de savoir si celui-ci reste suffisant a ces tres hautes tensions pour qu il soit possible d obtenir une image de qualite

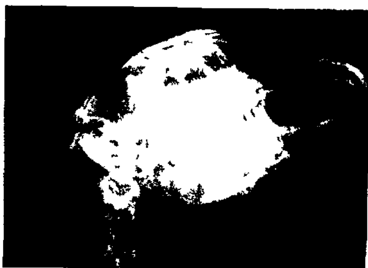


Fig 5 Tête de lapin radiographiée à 160 kV sur couple film industriel+écrans de plomb de 0 02 mm



Fig 6 Tête de mouton radiographiée à 300 kV sur couple film industriel+écrans de plomb de 0 02 mm

Si l on se réfère aux notions classiques, il faut croire que non En effet, si l on considère les courbes classiques qui montrent la variation du coefficient massique d absorption de l os, du muscle et de la graisse en fonction de la tension (Fig 3) on voit que ces courbes se croisent un peu au delà de 300 kV Le contraste devrait alors devenir pratiquement nul



Fig 7 Arteriographie de l artère axillaire chez le lapin (realisee par montee d un catheter dans la carotide primitive) a 160 kV sur couple film industriel + ecrans de plomb

En realite il n en est rien pour le verifier nous avons radiographie avec un appareil industriel mis a notre disposition par la C G R des epaisseurs croisantes de graisse de muscle et d os La structure tres heterogene de ces materiaux ne nous a pas permis de faire des mesures de densite mais le simple examen des images montre qu a epaisseur egale de ces differents objets il persiste un certain contraste

Lorsqu on passe a l etude du crane d excellents resultats sont obtenus sur crane sec et qui prouvent qu il est possible d obtenir de tres bonnes images du crane osseux en tres hauts voltages

Ainsi la Fig 4a montre un rocher radiographie a 300 kV en incidence axiale La definition de l image est remarquable malgre le gros foyer de l appareil industriel La Fig 4b represente le meme rocher radiographie en incidence de Stenvers l image est egalement tres bonne

Lorsqu on passe du crane sec a la tete d excellents resultats sont encore obtenus tant qu il s agit d animaux de volume moyen Ainsi nous avons obtenu une tres bonne image d une tete de lapin a 160 kV (Fig 5) et d une tete de mouton (Fig 6) a 300 kV

Mais chez l homme les choses se compliquent Les essais que nous avons faits sur fantome ne nous ont pas permis d obtenir des images de la qualite des precedentes

Nous avons d abord pense que la cause de ceci etait le rayonnement diffuse devenu trop important En realite des essais faits avec un test forme d une petite plaque d acier percee de trous extremement fins nous permettent de penser qu il n en est rien

De plus nous nous sommes aperçus que si l on radiographiait le fantome de façon à obtenir une image lisible sur un negatoscope ordinaire l image etait grise et insuffisamment detaillee Mais si l on expose davantage l image devient tres dense et ne peut plus etre lue qu a l aide d un eclairage puissant mais les

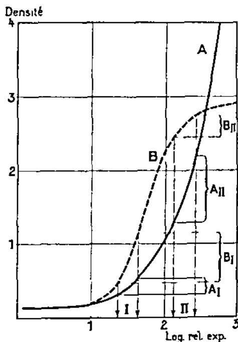


Fig 8 Courbe caractéristique des couples film industriel + écrans de plomb (A) et film médical + écrans fluorescents (B) Le contraste est plus important avec le film médical (BI) qu'avec le film industriel (AI) lorsqu'on travaille près du pied de la courbe (I) Mais si l'on travaille à des densités élevées par exemple de façon à ce que la densité maximale soit proche de 3 (II) le contraste devient beaucoup plus élevé avec le film industriel (AII) qu'avec le film médical (BII)

détails apparaissent Nous verrons que cela s'explique très bien lorsque l'on étudie la courbe de noircissement du film

Un autre problème important pour appliquer la technique haute tension à la neuroradiologie était celui du comportement de nos produits de contraste

Pour l'étudier nous avons d'abord fait une artériographie de l'artère axillaire chez un lapin à 160 kV, sur film Structurix avec écrans de plomb (Fig 7) Nous voyons que le contraste reste très suffisant de plus la définition de l'image est remarquable et il est possible d'y lire des vaisseaux de calibre extrêmement fin

Pour étudier le comportement des produits de contraste à des tensions plus élevées, nous avons utilisé des cathéters de polyéthylène remplis de diocolipiodol et d'un triiode hydrosoluble utilisé couramment en angiographie cérébrale (Radioselectan à 60 %) Puis nous avons radiographié les cathéters à 150 et à 300 kV, avec différents temps de pose et nous avons mesuré la densité des images obtenues Nous avons répété la même expérience avec les mêmes cathéters remplis d'eau, dont le coefficient d'absorption est sensiblement le même que celui des tissus mous

Puis nous avons porté les résultats obtenus sur la courbe caractéristique du film Structurix D 7

Étude de la courbe de noircissement La courbe caractéristique des films industriels (Fig 8) est très différente de celle des films médicaux classiques utilisés avec écrans fluorescents Elle est caractérisée par un pied très étendu suivi d'une

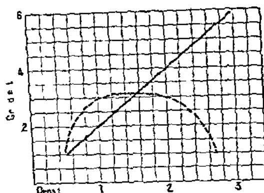


Fig 9 Variation du gradient en fonction de la densite pour les couples film industriel avec ecrans de plomb (—) et film medical avec ecrans fluorescents (— — — —)

montee rapide et constante du gradient Il n'y a pas de partie rectiligne, c'est-a-dire de zone ou le contraste est constant De plus le gradient de ce film est tres eleve et ne cesse de croitre, l'epaule de la courbe n'apparaissant pas pour des *densites mesurables* Il en resulte que le contraste est plus important avec le film medical (B) qu'avec le film industriel (A) tant qu'on travaille a de faibles densites Mais avec le film medical, le gradient va devenir constant dans la *partie* rectiligne de la courbe pour diminuer ensuite tres *vite lorsqu'on s*'approche de l'epaule tandis qu'avec le film *industriel il ne cesse de croitre* de sorte que si *l'on travaille a* de fortes densites le contraste est beaucoup plus important sur le *film industriel*

La variation du *gradient en fonction* de la densite est montree par la Fig 9 Elle montre bien qu'avec le film *medical celui-ci* croit d'abord rapidement pour devenir constant puis decroit tres rapidement a partir des den*sites voisines de* 2, tandis qu'avec le film industriel il ne cesse de croitre

Il resulte de tout ceci que des differences d'absorption meme minimes produites par l'objet pourraient etre mises *en evidence* avec un contraste suffisant par le film industriel avec *ecrans de plomb* a condition que l'on travaille a des densites suffisantes

En plaçant maintenant sur la courbe de *noircissement* les densites obtenues en radiographiant nos produits de contraste a 150 kV (Fig 10) l'ecart des densites entre les produits de *contraste* et l'eau varie suivant la region de la courbe ou l'on travaille pres *du pied* de la courbe l'*ecart entre* Radiosélectan et eau n'est que de 0 4 ce qui est faible *mais si* l'on augmente l'exposition de façon a ce que la densite maximale du cliche soit *proche* de 3 l'ecart devient egal à 1 1, ce qui represente un contraste important

Avec 300 kV le *contraste* est moins important mais on retrouve le meme

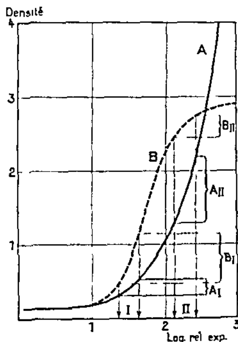


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Étude de la courbe de noircissement La courbe caracteristique des films industriels (Fig 8) est tres differente de celle des films medicaux classiques utilises avec ecrans fluorescents Elle est caracterisee par un pied tres etendu suivi d une

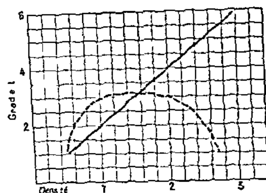


Fig 9 Variation du gradient en fonction de la densité pour les couples film industriel avec écrans de plomb (—) et film médical avec écrans fluorescents (— — — —)

montée rapide et constante du gradient Il n y a pas de partie rectiligne c est a dire de zone ou le contraste est constant De plus le gradient de ce film est tres eleve et ne cesse de croitre l epaule de la courbe n apparaissant pas pour des densites mesurables Il en resulte que le contraste est plus important avec le film medical (B) qu avec le film industriel (A) tant qu on travaille a de faibles densites Mais avec le film medical le gradient va devenir constant dans la partie *rectiligne* de la courbe pour diminuer ensuite tres vite lorsqu on s approche de l epaule tandis qu avec le film industriel *il ne cesse de croitre* de sorte que si l on travaille a de fortes densites le contraste est beaucoup plus *important* sur le film industriel

La variation du gradient en fonction de la densite est montree par la Fig 9 *Elle* montre bien qu avec le film medical celui ci croit d abord *rapidement* pour devenir constant puis decroit tres rapidement a partir des densites voisines de 2 tandis qu avec le film industriel *il ne cesse de croitre*

Il *resulte* de tout ceci que des differences d absorption meme minimes produites par l objet pourraient etre mises en *evidence* avec un contraste suffisant par le film industriel avec ecrans de *plomb* a condition que l on travaille a des densites suffisantes

En plaçant maintenant sur la courbe de *noircissement* les densites obtenues en radiographiant nos produits de contraste a 150 kV (Fig 10) l ecart des densites entre les produits de *contraste* et l eau varie suivant la region de la courbe ou l on travaille pres du pied de la *courbe* l ecart entre Radioselectan et eau n est que de 0 4 ce qui est faible *mais si* l on augmente l exposition de façon a ce que la densite maximale du cliche soit *proche* de 3 l ecart devient egal à 1 1 ce qui represente un contraste important

Avec 300 kV le contraste est moins important mais on retrouve le meme

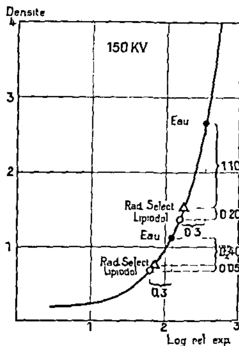


Fig. 10. Densités obtenues en radiographiant du Radioselectan, du Discolipiodol et de l'eau à 150 kV sur couple film Structurix D 7 + écrans de plomb. Si l'on travaille près du pied de la courbe caractéristique, l'écart des densités entre eau et Radioselectan n'est que de 0,40, ce qui est très faible. Si l'on travaille à des densités plus élevées (densité maximale du cliché proche de 3), l'écart entre eau et Radioselectan devient égale à 1,10, ce qui est important.

phénomène, et pour une densité maximale proche de 3, l'écart des densités entre Radioselectan et eau est de l'ordre de 0,8, ce qui représente un contraste assez important.

Discussion

L'utilisation de très hauts voltages en neuroradiologie est donc théoriquement possible, mais à condition de travailler à des densités élevées.

Malheureusement, des films ainsi exposés ne sont pas lisibles sur les négatoscopes médicaux actuels. A ce sujet, il faut reconnaître d'ailleurs que ces négatoscopes, adaptés à la vieille radiologie classique, sont fort peu lumineux. Ceci est tellement vrai qu'ils sont généralement doublés, dans la plupart de nos installations, par un spot puissant. Il serait certainement facile aux constructeurs, avec les tubes dont on dispose actuellement, de faire des plages lumineuses beaucoup mieux adaptées à la radiologie moderne.

Mais ceci ne serait sans doute pas suffisant pour résoudre le problème de la haute tension. D'autant plus qu'au problème de la densité de l'image se superpose celui de la dose reçue par le malade lorsque l'on supprime les écrans fluorescents. Nous avons commencé à faire des mesures à ce sujet, et il est certain que les films industriels actuels sont beaucoup trop lents.

En definitive au point ou nous en sommes de nos travaux il semble bien que la seule solution possible au probleme de la haute tension soit la creation d un nouveau film specialement conçu pour cette technique

Les caracteristiques que devrait avoir un tel film sont faciles a determiner sensibilite beaucoup plus grande maximum de sensibilite se situant aux environs de 250 ou 300 kV, gradient tres eleve et pied de la courbe de noircissement aussi peu etendu que possible

La realisation d une emulsion de ce type n est pas impossible et nous pensons pouvoir en essayer une dans un tres proche avenir

Un autre probleme reste egalement a etudier celui du convertisseur Nous avons utilise des ecrans de plomb parce que ceux-ci sont couramment utilises dans l industrie Mais il n est pas prouve que le plomb soit le metal le plus interessant

Conclusion

La radiologie en tres haute tension avec ecrans metalliques est une technique qui nous parait du plus haut interet Elle permet d obtenir des cliches plus riches en information que les cliches classiques et d une meilleure definition

Cette technique est utilisable des maintenant tant qu il ne s agit que de radiographier les membres en utilisant un film industriel et des ecrans de plomb

Pour l etendre a d autres domaines de la radiologie et en particulier a la *neuroradiologie* il est indispensable de disposer d une nouvelle emulsion *specialement* adaptee a cette technique et dont l etude fera l objet d un prochain travail

RÉSUMÉ

En depit de la notion classique d apres laquelle le *contraste entre os graisse et muscle* devient pratiquement nul pour des tensions de l ordre de 300 kV il est possible d obtenir des clichés suffisamment contrastes *avec de tels voltages* a condition de remplacer le couple film medical + ecrans fluorescents par un couple *film industriel* + ecrans de plomb et de travailler a des densites élevées Avec la technique decrite les produits de contraste lipo et hydro-solubles fournissent encore un très bon contraste *et il est possible d obtenir des images* d une definition remarquable et tres *riches en informations* Pour que la methode puisse etre utilisee chez l homme il faudrait cependant disposer d un film beaucoup plus rapide que *les films industriels actuels* et ayant *une courbe* de noircissement dont le pied serait aussi peu etendu que possible

SUMMARY

Contrary to the accepted view that contrast between bone fat and muscle is almost null at voltages in the 300 kV range the author has shown that films with sufficient contrast density can be obtained at these voltages *if the conventional* combination of medical film+

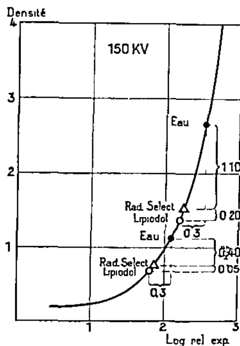


Fig 10 Densites obtenues en radiographiant du Radioselectan du Discolipiodol et de l eau à 150 kV sur couple film Structurix D 7 + ecrans de plomb Si l on travaille près du pied de la courbe caracteristique l ecart des densites entre eau et Radioselectan n est que de 0 40 ce qui est tres faible Si l on travaille à des densites plus elevées (densite maximale du cliche proche de 3) l ecart entre eau et Radioselectan devient egale à 1 10 ce qui est important

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FRANCE

CENTRAGE SAGITTAL-MEDIAN DANS LES RADIOGRAPHIES UNILATERALES COMPARATIVES DU CRANE

par

P R DORLAND et J PEREZ

Les radiographies segmentaires du crane qui mettent en evidence les divers orifices sont obtenues classiquement en inclinant soit le crane soit le rayonnement soit en combinant les deux methodes de façon a passer par des points d entree et de sortie connus (Fig 1 gauche, en haut)

Le systeme de centrage intra cranien de DELAC (1956) consiste a amener la region a radiographier au centre de rotation du craniographe puis à incliner le tube selon des angles definis Mais il a l inconvenient de deplacer le fauteuil lorsque l on passe d un cote a l autre et ce decalage de quelques centimetres n est pas toujours aussi facile et precis qu on le souhaiterait (Fig 1, droite en haut)

Le centrage sagittal median permet de viser successivement le cote droit puis le cote gauche et de les projeter sur le meme film geometriquement tout se passe comme si le foyer de roentgen etait situe au milieu du crane et pouvait etre deplace dans son plan sagittal median (Fig 1 *gauche en bas*)

Les points de centrage median sont determines sur les schemas radiographiques de la tete (en position de Hirtz et en *profil*) la construction geometrique est effectuee a partir des incidences usuelles (Fig 2)

fluorescent screen is replaced by a combination of industrial film+lead screen and the work is carried out at high densities. With the technique described, lipo- and water-soluble contrast media still give good contrast; it is possible to achieve roentgenograms of excellent definition and rich in detail. For application in man, however, it will be necessary that industrial film of considerably higher sensitivity, with a blackening curve having as narrow a basic range of values as possible, be made available.

ZUSAMMENFASSUNG

Im Gegensatz zur klassischen Auffassung, dass der Kontrast zwischen Knochen, Fett und Muskulatur im 300 kV Bereich Null ist, lassen sich genügend kontrastreiche Filme bei derartigen Spannungen erhalten, wenn man die konventionelle Kombination eines medizinischen Filmes mit Fluoreszenzschirm durch die Kombination eines industriellen Filmes mit Bleischirm ersetzt. Mit dieser Technik und unter Anwendung von öligen und wasserlöslichen Kontrastmitteln lassen sich gute und detaillierte Bilder herstellen. Für die Verwendung beim Menschen sind allerdings wesentlich empfindlichere Filme als die industriellen mit einer Schwärzungskurve möglichst nahe dem Basisbereich notwendig.

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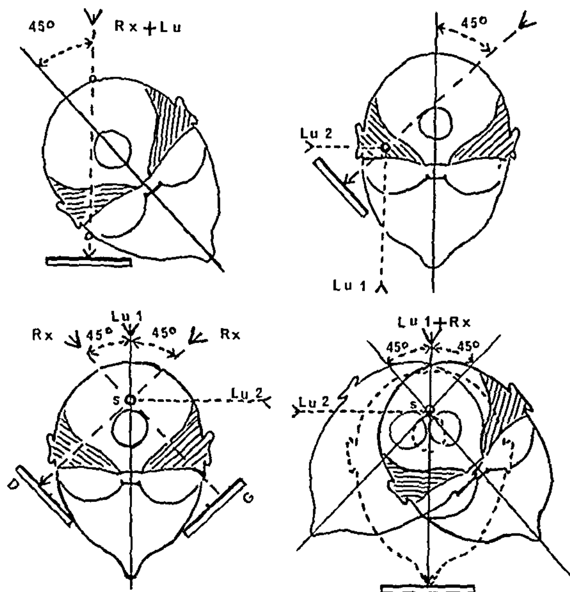


Fig. 1. Méthodes de centrages des radiographies segmentaires du crâne.

Méthode classique (gauche en haut). Il s'agit de faire passer le rayon principal par des repères cutanés en inclinant la tête latéralement et le tube dans l'axe longitudinal de la table.

Centrage intra-crânien de DULAC (droite en haut). La structure à radiographier est amenée dans l'axe de rotation du craniographe à l'aide des centreurs lumineux Lu 1 et Lu 2. Toutes les inclinaisons du tube sont possibles sans changer le centrage. La tomographie est facile mais l'examen de l'autre côté nécessite un nouveau centrage.

Centrage intra-crânien médian (en bas). Le plan sagittal médian du crâne est placé dans l'axe vertical de l'appareil à l'aide du centreur lumineux Lu 1. Puis le centrage latéral est effectué à l'aide du centreur Lu 2.

Au *craniographe* un seul mouvement du tube permet de comparer successivement les deux côtés (rotation autour du point S) (gauche en bas).

Avec un *appareillage plus simple* (type tomographe vertical mobile dans une seule direction) la comparaison des deux côtés pourrait être effectuée par rotation du siège à condition que le point de centrage puisse être amené dans l'axe du pivot du siège (*droite en bas*).

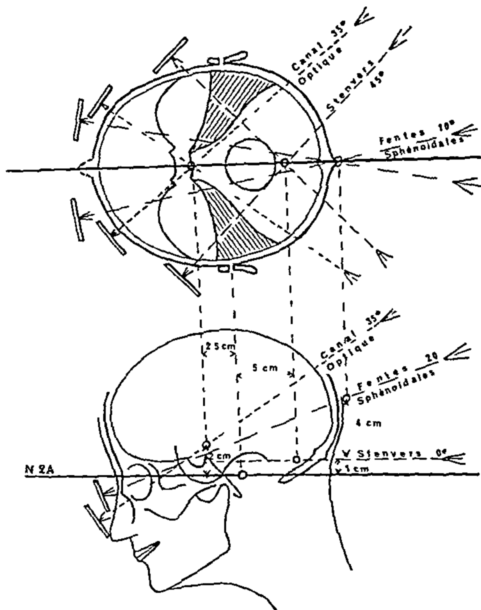


Fig 2 Reperage sur le prof l le plan N2A etant horizontal des points de centrage medians permettant la radiograph e symétrique des canaux optiques des fentes sphenoidales et des rochers (Stenvers)

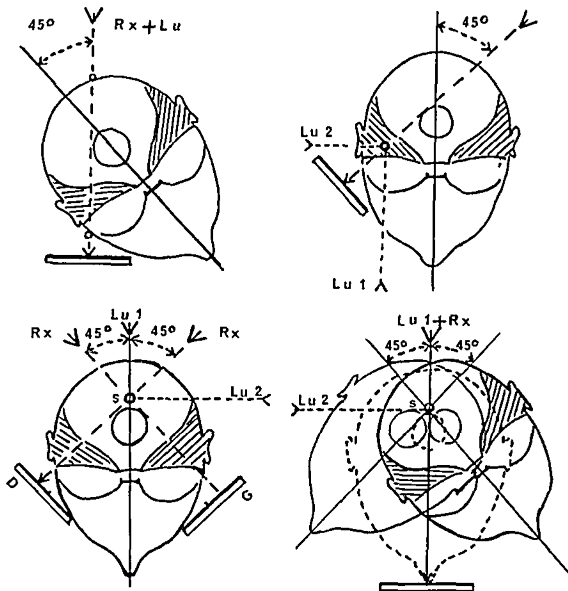


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Fig 4 Radiographie comparative des rochers (Stenvers à 40)

On déplace ensuite le patient et le craniographe de manière à faire coïncider l'axe horizontal avec le point de repère latéral

Si la tête a été fixée de telle sorte que le plan de Virchow soit horizontal il n'y a pas d'inclinaison à donner au tube puisque le rayonnement reste parallèle à ce plan il suffira d'incliner successivement de 45° de chaque côté dans le plan horizontal, pour obtenir l'image comparative des deux rochers (Fig 4)

Les incidences voisines du Stenvers sont faciles à obtenir en modifiant soit le point de centrage médian soit l'angle de rotation dans le plan horizontal

Discussion

L'avantage majeur de cette méthode est que le patient étant placé en bonne position au début de l'examen il n'est plus nécessaire de le déplacer pour étudier l'autre côté On peut projeter les deux côtés sur la même plaque ou par des variations d'angle de 5° ou 10 obtenir des vues légèrement différentes de la même région sur un même film

Si l'on veut examiner successivement plusieurs régions du crâne seul le point de repère latéral est à modifier puisque le plan sagittal médian reste toujours dans l'axe vertical du craniographe

La plupart des appareils de craniographie donnent la possibilité d'effectuer des coupes dans la même position que les clichés standards La technique décrite ne permet pas de le faire facilement puisque l'axe de rotation est situé à distance de la région intéressée il s'agit avant tout d'une méthode comparative qui a ses limites



Fig 3 Radiographie comparative des deux canaux optiques sur le même film

Radiographies des canaux optiques Le point médian est situé à la rencontre des deux axes, soit à quelques millimètres au dessus et en arrière de la lame quadrilatère

Le repérage de ce point sur le profil est facile il se projette à 3 cm au dessus d une ligne unissant l angle externe de l oeil au conduit auditif, et à 2,5 cm en avant de cet orifice

La tête du sujet étant immobilisée de telle sorte que le plan de Virchow soit horizontal, on amène le plan sagittal du crâne dans l axe vertical du crâniographe

On mobilise ensuite le fauteuil et le crâniographe de telle sorte que l axe horizontal de celui ci passe par le point de repère latéral

Les faisceaux lumineux facilitent grandement ces manoeuvres

Dans ces conditions, le centre de rotation du crâniographe correspond au point de repère médian des canaux optiques l inclinaison de 20° par rapport au plan de Virchow sera d abord donnée, puis on inclinera successivement de chaque côté de 35° par rapport au plan sagittal pour obtenir l image comparative des canaux (Fig 3)

Rochers en position de Stenvers La construction géométrique montre que le point sagittal médian est situé à 2 cm en arrière et au dessus du bord postérieur du trou occipital

Sur le profil, ce point se projette au milieu d une ligne unissant le conduit auditif à la protubérance occipitale externe

Comme précédemment, le plan sagittal du crâne est placé dans l axe vertical du crâniographe



Fig 4 Radiographie comparative des rochers (Stenvers à 50)

On deplace ensuite le patient et le craniographe de maniere a faire coincider l axe horizontal avec le point de repere lateral

Si la tete a ete fixee de telle sorte que le plan de Virchow soit horizontal il n y a pas d inclinaison a donner au tube puisque le rayonnement reste parallele a ce plan il suffira d incliner successivement de 45° de chaque cote dans le plan horizontal pour obtenir l image comparative des deux rochers (Fig 4)

Les incidences voisines du Stenvers sont faciles à obtenir en modifiant soit le point de centrage median soit l angle de rotation dans le plan horizontal

Discussion

L avantage majeur de cette methode est que le patient etant place en bonne position au debut de l examen il n est plus necessaire de le deplacer pour etudier l autre cote On peut projeter les deux cotes sur la meme plaque ou par des variations d angle de 5° ou 10°, obtenir des vues legerement differentes de la meme region sur un meme film

Si l on veut examiner successivement plusieurs regions du crane seul le point de repere lateral est a modifier puisque le plan sagittal median reste toujours dans l axe vertical du craniographe

La plupart des appareils de craniographie donnent la possibilite d effectuer des coupes dans la meme position que les cliches standards La technique decrite ne permet pas de le faire facilement puisque l axe de rotation est situe a distance de la region interessee il s agit avant tout d une methode comparative, qui a ses limites

L'etude analytique detaillee, par cliches standards sous divers angles, et par tomographies, necessite le centrage precis sur une structure donnee, imagine par Chausse et ameliore par DULAC

Le centrage sagittal median est particulierement facile a realiser avec les craniographes modernes, le tube peut tourner autour du crâne dans tous les plans, et seul le centrage median evite de mobiliser le sujet

On peut être ainsi amene a effectuer des radiographies reputees delicates sur des traumatises, car les schemas s appliquent aussi bien a la position allongee qu'a la station assise

Un certain nombre de fractures de la voûte du crâne seraient plus faciles a localiser sur des cliches effectues symetriquement en oblique des deux côtes, que sur les incidences faces et profils actuelles

La presence des deux côtes sur la même plaque facilite toujours la comparaison et evite la manipulation fastidieuse des films (determination du côte, recherche du film symetrique parmi de nombreux autres)

En plus des craniographes pour lesquels elle est toute indiquee, cette methode peut être appliquee a d autres appareillages, tels que les tomographes verticaux En effet, dans ce cas, on peut amener le plan sagittal median du crâne dans l axe d oscillation du tomographe, ce qui permet d obtenir l inclinaison voulue dans ce plan

L impossibilite d incliner le tomographe par rapport au plan sagittal peut être compensee par une rotation du siege

Il faut alors disposer d un siege pivotant, reglable en hauteur, des centrages lumineux doivent permettre d amener le point de repere median dans l axe de rotation du siege

Conclusion

La methode de centrage sagittal median que nous proposons est adaptable d emblee aux crâniographes modernes Elle peut être eventuellement appliquee a des appareillages plus simples dans lesquels ampoule et porte films sont solidaires, a condition de disposer d un siege pivotant special Elle permet d obtenir aisement sur un même film deux vues comparatives droite et gauche de toutes les radiographies segmentaires du crâne, qui doivent ainsi entrer dans la routine la plus courante

RÉSUMÉ

La radiographie unilaterale comparative du crane consiste a utiliser un centrage intra cranien médian Chaque point de centrage est différent suivant la region examinee mais il est toujours situe dans le plan sagittal median La methode peut etre appliquée avec des

appareillages simples dans lesquels ampoule et porte films sont solidaires mais l'utilisation d'un craniographe est préférable. Elle permet d'obtenir aisément sur un même film deux vues comparatives droite et gauche de toutes les radiographies segmentaires du crâne qui doivent ainsi entrer dans la routine la plus courante.

SUMMARY

Comparative unilateral radiography of the skull may be achieved by intracranial median centering. The centering points differ according to the region examined but are always in the sagittal median plane. The method can be employed with simple equipment but the use of a special skull table is preferable. Two right and left comparative views of all radiographic sections of the skull can easily be obtained on one and the same film. It is suggested that the method is useful in the current routine examination of the skull.

ZUSAMMENFASSUNG

Eine unilaterale vergleichende Röntgenuntersuchung des Schädels kann mittels intrakranieller medialer Zentrierung durchgeführt werden. Die Zentrierungspunkte sind verschieden und von dem Untersuchungsgebiet abhängig, aber sind immer in der sagittal medialen Ebene lokalisiert. Die Methode kann zusammen mit einfachen Ausrüstungen verwendet werden, obwohl ein Schädeltisch zu empfehlen ist. Zwei rechts und links einige vergleichbare Röntgenogramme verschiedener Abschnitte des Schädels können auf dem selben Filme leicht dargestellt werden und die Methode sollte deshalb unter den routinemässigen Untersuchungen des Schädels eingeordnet werden.

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SELECTIVE GASSERIAN INJECTION FOR TIC DOULOUREUX

Technical advances and results

by

ARTHUR ECKER and THEODORE PERL

Major trigeminal neuralgia, or tic douloureux, is characterized by violent, brief, paroxysmal attacks of facial pain, generally in persons over 40 years of age These attacks are characteristically produced by tactile stimuli at trigger areas of the skin or mucous membrane of the cheek lips, tongue or alveolar processes In less than 3 per cent of the cases the pain arises from the forehead, eyebrow or eye

Our goal is to produce prolonged or permanent total anesthesia to light touch in the trigger areas while preserving corneal sensation This result is obtained by selective denervation of axones from the mandibular and maxillary areas while sparing those from the ophthalmic division

In the past 13 years we have relieved tic douloureux without permanent ill effect, by precise alcoholic Gasserian injection in 234 successive cases, after other methods of treatment had failed to provide prolonged relief of pain (ECKER & PERL 1965) Almost all patients had been given a trial of medical therapy consisting of diphenylhydantionate sodium (dilantin) or carbamazepine (tegretol) several had undergone alcoholic injection of peripheral nerves 16 had surgical rhizotomy One fourth of the patients were over 70 years of age at the time of injection Both for them and for others with systemic disease the risk of craniotomy would have been higher

We use the anterior approach through the cheek and foramen ovale with meticulous radiographic guidance (PERL & ECKER 1963, Figs 1 and 7) In this

way the needle is brought through the center of the foramen ovale and lies 4 mm deep to it as measured in a submentovertical (axial) projection of the skull With the patient supine the head extended and rotated toward the healthy side a minute amount of absolute alcohol 0 05 ml, is injected The resulting anesthesia is tested promptly and repeatedly To control its extent and intensity, adjustments may be made in the depth and rotation of the needle the timing and amount of subsequent injections and the position of the patient s head If the trigger area remains totally anesthetic to the light tactile stimulus for 30 minutes there is a very high probability that the patient will be permanently relieved of trigeminal neuralgia The permanence of anesthesia depends on failure of regeneration of fibers of the sensory root and its intra axial extensions

Technique

Preparation of the patient Each patient has a complete neurological examination and complete radiographs of the skull In a younger patient the possibility of multiple sclerosis is considered but is not a contraindication Unilateral deafness of the nerve type is an indication for special study for an acoustic nerve tumour

Before the day of the injection the nature of the residual anesthesia is carefully explained to the patient Those who have had successful alcoholic injections of the peripheral nerves have already had such an experience Some others have difficulty in understanding the distinction between numbness and paralysis For many patients especially women the loss of sensation in part of the face is a personal threat We try to create a desire in the patient for permanent anesthesia at the trigger areas as the best assurance that the pain will not recur If there are pre operative paresthesias these are likely to remain For example some patients have a painless signal a characteristic sensation, immediately before the onset of pain After appropriate anesthesia has been produced the signal will persist but no pain will follow Furthermore about half the patients have a positive sensation of numbness and of crawling We prepare the patients for these sensations and describe them as evidence of the unsuccessful attempt of the nerve to regenerate

On the day of the injection the patient is carefully instructed in a series of hand signals indicating degrees of intensity of light touch sensation During testing we always demonstrate the touch sensation on the healthy side When we do so the patient is to raise 4 fingers Three fingers indicates three fourths of this sensation two fingers one half and one finger one fourth A closed fist corresponds to zero or complete lack of sensation

Because of some risk of retching probably caused by apprehension the patient should have nothing by mouth for 4 hours before the procedure At the start of the procedure the patient is given an intramuscular injection of 50 mg of meperidine (demerol) or a smaller dose if he is light in weight or very advanced in years If there is nausea or vomiting an intramuscular injection of prochlorperazine (compazine) 10 mg is given

Radiographic determination of the head position and entry point A line is drawn on the skin in the mid sagittal plane on the forehead (the sagittal line) and another on the affected side from the external canthus of the eye to the

external auditory canal (the orbitomeatal line) A mark, the preliminary entry point, is made on the cheek midway between the lateral wall of the maxillary sinus and the ascending ramus of the mandible at the level of the mouth

Tincture of benzalkonium (zephiran) is applied to the cheek and an antiseptic sprayed in the mouth near the tissues where the needle will pass Twenty milliliters of 1 per cent lidocaine (xylocaine) are injected into the cheek along the intended path of the needle, mostly in the tissues medial to the coronoid process where a gloved finger in the mouth feels the mucous membrane bulge This injection provides local anesthesia for the needle insertion, minimizes the chance of intra oral penetration of the needle and fixes the skin at the entry point (ECKER & PERL 1965, Fig 1)

The patient is placed supine on the radiographic table with the body elevated on a *mattress A large sponge rubber wedge rests under the shoulder of the af*fected side A square wire grid, 2 cm on a side, is taped to the cheek with its center at the preliminary entry point The head is extended over the upper edge of the mattress until the orbitomeatal line makes an angle of 70° with the vertical Then the head is rotated toward the healthy side until the sagittal line makes an angle of 20° with the vertical, the sagittal needle angle (PERL & ECKER 1963, Fig 2) Sponge rubber blocks support the head The radiologist and the technician at the side and head of the table, respectively, determine accurate positioning of the head by simultaneous sighting through transparent plastic guides (PERL & ECKER 1963 Fig 3)

The preliminary roentgenogram is made with the central ray directed through the preliminary entry point This film shows the grid superimposed on the foramen ovale (PERL & ECKER 1963, Fig 4) The foramen ovale is usually easily seen in this projection Ideally, its inferior margin will coincide with the line of the petrous ridge Occasionally, it is not seen even with the aid of the petrous line A repeat radiography with increased extension of the head to 75 degrees may make it visible A cell in a pneumatized petrous tip, a laterally placed extension of the sphenoidal sinus or a thin area in the floor of the middle cranial fossa may simulate it Before selecting the final entry point, one must be certain of properly identifying the foramen ovale

If, on the film, the foramen appears slit like with too short a distance between its superior and inferior edges (actually anteromedial and posterolateral borders), the head is extended further so that the orbitomeatal line makes an angle of more than 70° with the vertical Increasing this angle widens the projection of the foramen Naturally this hyperextension brings the entry point to a more inferior level on the cheek If necessary, the grid is replaced at a lower level on the cheek The preliminary roentgenogram is repeated as necessary

JEFFERSON (1963) has pointed out the inadvisability of the needle s penetrat



Fig 1 Roentgenograms with modified end on needle projection a) Needle enters the foramen ovale eccentrically b) Needle corrected to central position c) Submentovertical projection of (b)

ing the lateral third of the foramen With this in mind when there is an unusually long foramen we increase the sagittal needle angle (by rotating the head even more than 20 toward the healthy side) so that the lateral third of the foramen lies behind the projection of the coronoid process The latter then prevents the needle from entering the lateral portion of the foramen After a satisfactory preliminary roentgenogram has been obtained the final entry point can be marked out by sighting from the tube position (as seen on the roentgenogram just medial to the center of the foramen ovale) on the cheek in relation to the grid The vertical line passing through this final entry point is the projected course of the needle

Needle insertion and adjustment with radiographic control While the corrected position of the head is maintained the grid is removed and the skin is sterilized again A disposable 10 cm long 22 gauge lumbar puncture needle is used The needle tip is placed at the entry point and advanced vertically downward with continuous biplane guidance (PERL & ECKER 1963, Fig 5)

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In the end-on needle projection that part of the needle traversing the foramen ovale should be seen to be medial to the exact center of the foramen ovale, i e at the juncture of its middle and medial thirds The needle should lie half way between the anteromedial and posterolateral borders of the foramen which appear in the film respectively as the superior and inferior edges (Fig 1b) The needle must be correctly centered for even if it has penetrated the foramen its tip may lie unfavorably extradural subdural or in the subarachnoid pace around the mandibular nerve Gasserian ganglion or root

If the needle is not perfectly positioned it may be corrected up to 2 mm in any direction (anteroposteriorly or mediolaterally) by withdrawing the needle approximately 2 cm Then the needle is rotated with the bevel opposite the side of intended correction The proximal part of the needle is inclined with hub deflected about 2 cm also opposite the side of intended correction, while the needle is advanced again to and through the foramen (Fig 1) Adjustments of the needle tip laterally or superiorly can be assisted by the operator s gloved finger in the oral cavity pressing against the needle

A correction of 4 to 6 mm is best made by inserting a second needle parallel to the first There is a natural tendency for the second needle to converge toward the first This tendency is prevented by keeping the bevel of the second needle on the side nearest the first The ski effect away from the first needle prevents convergence and keeps the needles parallel

If the first needle is more than 6 mm out of line it will not penetrate the foramen Common errors that cause gross misplacement of the needle are (1) change of the position of the head or the entry point from that of the corrected preliminary film (2) failure to maintain a truly vertical position during the insertion If after these three factors have been checked the needle still does not penetrate the foramen it is best to start again by replacing the grid and establishing a new final entry point

If the tip of the needle (as demonstrated on the submentovertical projection) is not precisely 4 mm deep to the foramen ovale its depth can be adjusted by sighting a ruler placed on the cheek alongside the needle and then elevating or depressing the needle the appropriate amount When the needle is in correct position the patient is assured that there will be no more severe pain Occasionally particularly in osteoporotic skulls the foramen is poorly seen in this view The most helpful guide is the identification of the foramen spinosum which can almost invariably be seen Again the small cone is helpful by improving detail

If there is doubt that the tip of the needle is correctly placed it is better to make a preliminary injection of 0 03 ml of procaine 1 % and to be sure of appropriate anesthesia results before injecting any alcohol



Fig 2 New radiographic technique for the submentovertical projection

The sighters from the head and side of the table must continually check (1) the precise position of the head, (2) the position of the entry point and (3) the verticality of the needle While advancing the needle slowly with continuous corrections by the two sighters, one also rotates it on its axis to avoid lateral deviation, ski effect, from the bevel

If there is a central collimator light, the shadow of the hub around the entry point can assist in controlling the vertical position of the needle during insertion

Penetration of the foramen ovale (and mandibular nerve) is determined by the production of momentary trigeminal pain, of which the patient has been fore warned The needle should penetrate about 4 mm

If the stylet fits too loosely in the needle we produce a spring like effect by bending it a little in its middle, thus stabilizing it within the needle Following a suggestion of PENMAN (1953), we withdraw the stylet approximately 7 mm thus, the distal 7 mm of the needle becomes less opaque (Fig 3)

Two films of the needle's position are exposed For the first, the head is rotated 5° medial to the position for needle insertion The film obtained with this modified end on needle projection confirms entrance of the needle through the foramen (Fig 1) For the second film in submentovertical projection we have devised a new technique (Fig 2) A cassette is inserted between the table top and the plastic sponges supporting the head The tube is tilted cephalad so that the central ray is (1) perpendicular to the basal plane (as indicated by the orbitomeatal line) and to the film and (2) is directed through the foramen ovale to the center of the film A 2 inch 'mastoid cone is used to improve detail (Fig 2) The head is laterally rotated so that the mandible on the affected side is elevated about 10° This maneuver rotates the foramen ovale so that its axis is penetrated by the central ray, which forms an angle of about 45° to the needle

as 0.05 ml. In such a case a larger quantity of alcohol, even if correctly injected, will over flow along the posterior root. This may spill into the cerebellopontine cistern, thus endangering the 7th or 8th cranial nerves and producing facial paralysis, dizziness or nystagmus.

Extremely small (0.05 ml) therapeutic injections of absolute alcohol are made and the time of injection is recorded. We employ 1 ml plastic tuberculin syringes which are very light in weight. For each routine injection 0.085 ml is placed in the syringe. Only 0.050 ml will be injected into the tissues since the remaining 0.035 ml is retained in the bore of the needle. The tuberculin syringe is allowed to remain in place. The patient is discouraged from talking because it may affect the depth of the needle. If the first injection is correct, there is usually a mild burning sensation in the trigger area followed by subjective numbness and anesthesia on testing. For each additional injection another 1 ml plastic tuberculin syringe loaded with 0.085 ml of absolute alcohol replaces the previous one. With each subsequent injection the amount of burning discomfort becomes progressively less. If severe pain should appear in the temple, usually the alcohol has been injected epidurally.

Sensory testing. Immediately after the injection and every minute or two thereafter careful sensory testing is performed throughout the trigeminal area semiquantitatively and topographically (ECKER & PERL 1958, Fig. 3 and p. 461) by the patient's responses to the light tactile stimulus of a cotton wool swab. The results are recorded. If there is impairment of touch sensation in the trigger areas but not in the forehead and cornea, no change is made; if sensation returns, the injection is repeated as necessary to produce persistent total anesthesia. Usually from 1 to 6 injections are required. If the anesthesia of the trigger area diminishes after 10 or more minutes, the depth of needle is re-checked by another submentovertical roentgenogram before more alcohol is injected. When the desired total anesthesia to light touch in the trigger areas persists for thirty minutes and pain is not produced even by firm pressure on these areas, the procedure is terminated. There is a very high probability that the patient will be permanently relieved of tic douloureux.

With this method, for unexplained anatomic reasons, anesthesia of the oral cavity often appears before anesthesia of the skin. Therefore those patients whose trigger areas lie entirely within the oral cavity can often be relieved of pain without significant cutaneous anesthesia.

We are particularly concerned with preserving corneal sensation. If the forehead and cornea become numb, the needle is immediately withdrawn 2 mm and the head is rotated more toward the healthy side so that the lighter alcohol will rise in the spinal fluid in Meckel's cavity in the direction of the fibers of the second and third division. In most cases the corneal anesthesia will disappear in 6 or 8 minutes. Since additional injections of alcohol are likely to follow the track of the needle made before partial withdrawal, thus producing permanent corneal anesthesia, we make a significant change in direction of the needle before proceeding with further alcoholic injection.

Results

We have carried out our procedure and prevented pain in 234 patients over the past 13 years. In most patients (75 % during a period of 1 to 12 years, 70 % 4 to 12 years) a single session of injection was required; in some (30 %) two injections were required, and rarely, three (ECKER & PERL 1965).



Fig 3 Roentgenogram in submentovertical position with needle properly placed the needle in this projection extends 4 mm beyond the posteromedial edge of the foramen ovale There is also a pterygo alar bar (ossified ligament) which caused no difficulty however

Therapeutic injection The trigeminal root is a more or less loose meshwork of fibers bathed in cerebrospinal fluid The ganglion is canoe shaped and joins the posterior root within 5 mm of the foramen (PERL & ECKER 1963 Fig 1) The ganglionic sinus is the hollow of the canoe at the junction of root and ganglion If cerebrospinal fluid escapes when the stylet is removed FIRNER S (1949) dissections and our experience indicate that the needle tip usually is among the fibers of the trigeminal root The needle is withdrawn slowly until the flow of fluid just ceases The needle tip is usually 2 or 3 mm deep to the posterior edge of the foramen ovale Now either the tip is in the ganglionic sinus or a track leads to this region In either case it is in an ideal location for injection

If no cerebrospinal fluid is obtained when the stylet is withdrawn the tip of the needle *is brought 4 to 5 mm deep to the posterior margin of the foramen ovale If blood appears* in the needle it is washed out by injecting sterile saline solution before alcohol is injected

For second division tic (i e trigger areas in the region of the maxillary nerve) a pillow is now placed under the head reducing the extension of the head so that the angle of the orbitomeatal line with the vertical is 50 and rotation increased so that the sagittal needle angle is 45 For third division tic the patient is placed partly on his healthy side with the head flexed laterally downwards These are more comfortable positions for the patient and allow the alcohol which is less dense than the cerebrospinal fluid to rise away from corneal fibers

JEFFERSON (1963) has demonstrated that the volume of Meckel s cavity may be as small

2 Similar precision in producing anesthesia is possible allowing for anatomic individuality

3 Injection of minimal amounts of absolute alcohol no more than 0 05 ml at a time is assured

4 If there is immediate unwanted anesthesia of the forehead and cornea prompt adjustments usually make this undesirable effect temporary Therefore, we produce long standing relief of pain comparable to that of other radical measures with no mortality and minimal morbidity

SUMMARY

Description of the authors technique of selective Gasserian injection for tic douloureux It requires co-operation of radiologist surgeon and patient and is based on the precise radiographic control of the placement of needle injection of minute quantities of absolute alcohol and careful clinical testing of extent and intensity of the sensory loss produced The results of the treatment in 234 successive cases that failed to respond permanently to other measures were excellent in two-thirds of the cases and satisfactory in an additional one quarter

ZUSAMMENFASSUNG

Die Verfasser beschreiben ihre Methode fur selektive Einspritzung des gasserschen Ganglion in der Behandlung von Trigeminusneuralgie Zusammenarbeit zwischen Rontgenologen, Chirurgen und Patienten ist notwendig da das Verfahren von folgenden Faktoren abhangig ist eine genaue rontgenologische Kontrolle der Nadeleinfuhrung und Injektion von sehr kleinen Mengen reinen Alkohols sowie eine sorgfaltige *klinische Untersuchung* der Ausdehnung und Intensitat des Sensibilitatsausfalles Die Wirksamkeit dieser Methode in 234 konsekutiven Fallen die mit anderen Massnahmen nicht langdauernd erfolgreich behandelt werden konnten war in zwei Drittel der Falle *ausgezeichnet* und in einem weiteren Viertel zufriedenstellend

RÉSUMÉ

Les auteurs decrivent leur technique d injection selective du ganglion de Gasser dans la nevralgie du trijumeau Elle necessite la *cooperation* du radiologiste du chirurgien et du malade et est basee sur le controle radiographique précis de la mise en place de l aiguille sur l injection de petites quantités d alcool *absolu et* sur la determination clinique soigneuse de l etendue et de l intensite de l anesthesie produite Dans 234 cas consécutifs qui n avaient pas cedé de façon permanente à d autres traitements les resultats de cette technique ont été excellents dans les deux tiers et satisfaisants *dans* un autre quart des cas

Most patients have permanent anesthesia or marked hypo esthesia of the right or left half of the lower face This region includes both the skin and mucous membrane of the lips, cheek and oral cavity with tongue and gums

Recently we traced 148 cases of 197 injected more than one year before Of these, 135 patients were still alive None was suffering from tic pain Sixty eight per cent of our patients are delighted with the result of the procedure and an other 27 per cent reasonably satisfied Five per cent suffered distressing par esthesia, described below

Complications There has been no death, blindness, aphasia, hemiparesis cranial nerve palsy or other serious permanent ill effect Ten per cent have cor neal anesthesia and must watch the eye for redness Seven patients (3 per cent) have had superficial keratitis and four required tarsorrhaphy Three had some diminution of visual acuity from a corneal scar (respectively to 20 40, 20/50, and 20/100 which later improved to 20/60)

Herpes simplex on the lips or oral mucosa is common but painless and usually limited to a few days Masticator nerve function on the side injected may be impaired temporarily, never longer than two months Therefore our method has been used safely in cases of bilateral tic douloureux No persistent cranial nerve palsies have occurred When part of the tongue is completely numb to touch, taste sensation is absent in that portion Early in the series there were three cases of meningitis (ECKER & PERL 1965) Two patients developed small superficial ulcers of anesthetic areas of the nostril These healed promptly when the patients stopped picking the skin

The overall results in terms of residual paresthesia and relief of pain are about the same with our method as those following craniotomy with surgical section of the root, injection with phenol or with boiling water A major unsolved problem with all these methods is paresthesia apparently the result of de afferentation Five per cent of patients (following either surgery or injection) are severely distressed by the abnormal sensation, usually described as crawling Some of these patients had had paresthesia before treatment those in our series and their relatives were forewarned that it would not be relieved We know of no useful medical or surgical treatment for this condition although tranquillizers and di phenylhydantoinate are prescribed

Conclusions

The advantages of the present technique over previous methods result from the following facts

1 That the tip of the needle can be precisely placed in relation to the base of the skull

2 Similar precision in producing anesthesia is possible allowing for anatomic individuality

3 Injection of minimal amounts of absolute alcohol, no more than 0 05 ml at a time is assured

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UTILISATION DES PRODUITS DE CONTRASTE HYDROSOLUBLES EN NEURORADIOLOGIE

par

R. GONSETTE et G. ANDRÉ BALISAUX

Les produits de contraste utilisés en neuroradiologie sont des composés iodés qui se classent d'après leurs propriétés physico-chimiques en substances liposolubles ou hydrosolubles. Ces propriétés jouent un rôle important dans la tolérance des divers organes à leur égard et font que les produits hydrosolubles sont réservés à l'opacification du réseau vasculaire, tandis que les composés liposolubles sont utilisés pour mettre en évidence les cavités ventriculaires ou les espaces arachnoïdiens.

Une tentative récente pour rompre cette tradition revient à DILENGE, GUERBET, DAVID et FISCHGOLD qui proposent, en 1965, une substance liposoluble utilisable pour l'opacification carotidienne. Des problèmes de tolérance vasculaire n'ont pas encore permis l'application de cette méthode chez l'homme.

Nos recherches s'orientent dans le sens inverse, c'est-à-dire vers l'utilisation des hydrosolubles pour la ventriculographie, la myélographie, la radiculographie.

Le problème majeur est le choix d'une substance de contraste.

Nous avons étudié leur neurotoxicité chez l'animal, en premier lieu par l'étude au microscope électronique de leur action sur le parenchyme cérébral après injection intracarotidienne, ensuite par l'observation clinique de leurs effets après injection intra-cérébrale, enfin par l'examen anatomopathologique des cerveaux prélevés.

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a



b

Fig 2 a) Ventriculographie effectuee avec le sel de methylglucamine de l acide iothalamique Excellent rendement du syst me ventriculaire supra et infratentoriel les plexus choro des sont bien visibles b) Myelographie lombo-sacree effectuee avec la substance MP 2032 Mise en évidence d un angiome du renflement lombaire

l animal un recul de 4 annees et des examens anatomopathologiques de pieces operatoires leur ont permis de publier cette technique en 1966 avec toutes les garanties necessaires

Nous avons utilise leur methode chez 50 malades sans aucune reaction subjective au moment de l examen Les suites sont moins penibles que pour les ventriculographies gazeuses peu de nausees et peu de reactions hyperthermiques

Cette nouvelle technique peut rencontrer notre scepticisme, particulierement en ce qui concerne son utilite

Outre le moulage parfait des cavites ventriculaires nous insistons sur deux

Nous avons sélectionné, parmi les hydrosolubles de fabrication récente et dont certains sont encore à l'étude, deux substances : l'acide iothalamique, et le produit expérimental MP 2032 formé de l'association de deux molécules d'acide iothalamique, toutes deux sous forme de sel de méthylglucamine.

Radiculographie lombo-sacrée. Depuis 1948, les substances hydrosolubles sont employées pour la radiculographie lombo-sacrée. On utilise des mono-iodés contenant un radical sulfoné, substance irritante nécessitant une rachianesthésie, non dépourvue de toxicité vis-à-vis du système nerveux et dont les séquelles sont parfois dramatiques.

Il paraît donc logique de les remplacer par les hydrosolubles récents, mieux tolérés et moins toxiques. Nous avons réalisé plus de 50 radiculographies avec le sel de méthylglucamine de l'acide iothalamique, sans rachianesthésie et sans la moindre douleur chez nos malades. Les images radiologiques sont de bonne qualité car la concentration du produit est double de celle des anciens hydrosolubles (méthiodal Kontrast U).

Il est nécessaire cependant de réaliser cet examen en position semi-assise car l'iothalamate peut provoquer une irritation médullaire se traduisant par des contractions involontaires des membres inférieurs. Quoique sans aucun danger et cédant rapidement au Valium, ces manifestations sont désagréables et mieux vaut les éviter. Nous devons signaler que la substance MP 2032 est dénuée de toute action irritative sur le parenchyme médullaire et n'expose plus à de tels inconvénients.



Fig. 1. Radiculographie lombo-sacrée effectuée avec le sel de méthylglucamine de l'acide iothalamique: examen pratiqué sans rachianesthésie. Contraste excellent permettant l'étude des diverses racines de la queue de cheval.

L'analyse du liquide céphalo-rachidien, 24 heures après la radiculographie, montre une légère augmentation de l'albumine et quelques éléments cellulaires. Ces réactions sont habituelles après une encéphalographie gazeuse. L'électrophorèse sur agar ne montre aucune modification.

Ventriculographie. Les premières ventriculographies par produits hydrosolubles ont été réalisées par HEIMBURGER dès 1962. Des expériences préalables chez

RÉSUMÉ

Les auteurs donnent un bref aperçu de leurs premières expériences cliniques avec des produits de contraste hydrosolubles (et donc resorbables) utilisés pour radioculographie lombo-sacree sans rachianesthésie et pour ventriculographie et myelographie Les avantages de ces nouvelles methodes neuroradiologiques dont certains constituent déja une améliora tion considerable par rapport aux techniques classiques sont brievement mentionnés

SUMMARY

The authors initial experiences with hydrosoluble (and thus resorbable) contrast media for use in lumbo-sacral radiculography without local anaesthesia and for ventriculography and myelography are briefly summarized The advantages of these new neuroradiologic methods are briefly discussed they are considered to constitute marked improvements in relation to the classical techniques

ZUSAMMENFASSUNG

Die Verfasser prasentieren einen kurzen Bericht uber ihre ersten klinischen Erfahrungen mit wasserloslichen (und also resorbierbaren) Kontrastmitteln fur lumbosakrale Radikulographie ohne Lokalbetaubung und fur Ventrikulographie und Myelographie Die Vorteile werden erwahnt und im Verhaltnis zum klassischen Verfahren kann es schon festgestellt werden dass in mancher Hinsicht die neuen neuroradiologischen Methoden markante Ver besserungen erbieten

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apports originaux : en premier lieu, le moulage excellent des citernes de la fosse postérieure et même des circonvolutions cérébelleuses, en second lieu, et ceci nous paraît important, le fait que la faible viscosité de ces substances leur permet de vaincre une sténose serrée de l'aqueduc infranchissable pour des substances liposolubles, même ultra fluides. Chez le même malade, il devient donc possible avec les hydrosolubles, de poser un diagnostic précis concernant la situation d'une lésion de la fosse postérieure, alors que les produits liposolubles indiquent simplement qu'il existe une obstruction de l'aqueduc.

Myélographie. Une dernière application des substances hydrosolubles concerne la myélographie.

Le sel de méthylglucamine de l'acide iothalamique ne peut être utilisé car, quoique bien toléré par les cavités ventriculaires et les racines de la queue de cheval, il provoque une hyperexcitabilité médullaire.

Le produit MP 2032, par contre, est dénué d'action convulsivante au niveau du système nerveux central ou irritante pour la moelle.

Nous avons réalisé dix myélographies par voie sous occipitale sans aucune réaction secondaire. Les images nous semblent particulièrement intéressantes, car il est ainsi possible d'apprécier le volume de la moelle, et dans certains cas, de mettre en évidence des lésions telles que les angiomatoses médullaires.

Conclusion

Nous croyons pouvoir dire que de nouvelles substances hydrosolubles nettement mieux tolérées par le système nerveux, pourront très prochainement être utilisées en neuroradiologie.

Pour les radiculographies lombo sacrées, le sel de méthylglucamine de l'acide iothalamique devrait, à notre sens, remplacer dès à présent les anciens monoiodés car ce produit ne nécessite pas de rachianesthésie, étant bien toléré par les racines de la queue de cheval.

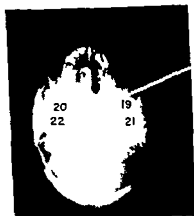
Pour les ventriculographies, les substances hydrosolubles trouvent des indications plus restreintes en apportant des informations là où d'autres substances ont échoué.

Pour la myélographie, le problème est encore à l'étude, quoique pratiquement résolu.

Bref, à côté de l'avantage majeur d'une élimination complète et rapide, les hydrosolubles apportent des images radiologiques bien contrastées, particulièrement nuancées et riches en information et des recherches dans ce sens méritent d'être poursuivies.







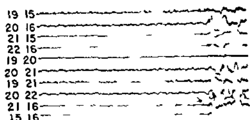


Fig 1 The spike focus is localized to the tip of the left anterior sphenoidal electrode as shown by the dotted lines Note the distance between the anterior and posterior tips and their relationship to the medial aspect of the inferior anterior temporal lobe an area frequently epileptogenic

1965) In addition the tip can be adjusted to lie in a more anterior or posterior position in relationship to the base of the skull (GRABOW 1968)

Sphenoidal electrodes likewise have some variability in position The sphenoidal electrode tip directed anteriorly monitors a different region than the one directed posteriorly (Fig 1) Epileptogenic activity at the left anterior sphenoidal electrode may not be seen at the left posterior sphenoidal electrode

With the greater use of standardized chronic depth probes with up to 18 contacts a few millimeters apart, *localization* is becoming more precise A recent patient with intractable daily seizures had bisynchronous bifrontal spike discharges from the scalp recordings However in the depth recordings the predominant activity came from the left frontal During the spontaneous seizure

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VALUE OF ROENTGENOLOGY IN ELECTRODE PLACEMENT TECHNIQUES IN ELECTROENCEPHALOGRAPHY

by

JACK D GRABOW

Roentgen examination can be useful in determining the exact position of scalp, nasopharyngeal, sphenoidal, and depth electrodes in EEG Routine EEG recordings usually monitor 18 electrodes arranged symmetrically on the scalp convexity If a spike discharge is found at one of the 18 sites, an additional 8 to 10 electrodes are placed around the abnormality The precise abnormal point is located by phase reversal techniques The disc scalp electrode or additional marker can be seen on the lateral, p a and basal views Better correlations can be made between the clinical seizures and the focal EEG abnormalities by means of radiographic documentation The persistency and consistency of the localization of the spike focus can be studied by similar methods in yearly follow ups There are cases with focal epileptogenic activity on the EEG in which no clinical seizures had occurred Knowledge of these brain areas may be helpful in studying some problems of epilepsy In planning seizure surgery the extent and site of the bone flap can be determined by viewing the roentgen films that accompany the EEG reports Neurosurgeons who are not familiar with electrode placement techniques find the usual EEG reports too vague when reference is made to specific brain areas

Nasopharyngeal electrodes have been shown by this author to cross in the nasopharynx if certain precautions are not taken during insertion (GRABOW

Acknowledgement

The work was supported by USPHS Grant B 3360 from NINDB

SUMMARY

Radiography may be useful for determining the exact position of scalp nasopharyngeal sphenoidal and depth electrodes in electroencephalography Roentgen films should be obtained after having localized a spike discharge by phase reversal techniques to a precise point The electrode or an additional marker can be used to document the site of the abnormality

ZUSAMMENFASSUNG

Rontgenographie mag von Wert sein um bei der Elektronzephalographie die exakte Lage der Elektroden an der Kopfhaut und Nasopharynx sowie die exakte Lage der sphenoidalen und Tief Elektroden zu bestimmen Mit Hilfe der Technik von Phasen Umkehr wird der Entladungsschlag zu einem bestimmten Punkt lokalisiert und Rontgenogramme werden dann aufgenommen Die Position der Missbildung kann mit den Elektroden oder mit einem zu satzlichen Indikator markiert werden

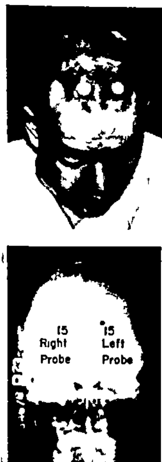
RÉSUMÉ

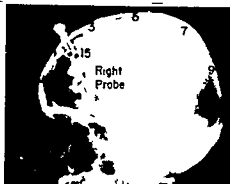
La radiographie peut servir en electroencephalographie pour déterminer la position exacte des électrodes sur le cuir chevelu dans le nasopharynx, et des électrodes sphénoidales et profondes On localise une decharge des pointes en un point précis par des techniques d inversion de phases et on prend des radiographies L électrode ou un autre marqueur peut servir pour indiquer le siège de l anomalie

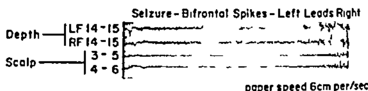
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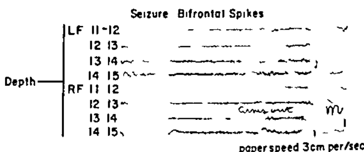


Fig 2 Depth study with frontal probes 18 contacts in each The upper four channel EEG tracing during a seizure shows numerous spikes occurring in the depth (LF 14—15 RF 14—15) Dots are placed at the focus which is contact 15 as seen in the lateral and p a views With the faster paper speed of 6 cm per second the spikes in the left frontal depth (LF 14—15) occur slightly before the spikes in the right frontal depth (RF 14—15) This was not always apparent with the normal paper speed of 3 cm per second (lower EEG tracing) or with scalp recordings In addition the spikes recorded from the scalp (3—5 and 4—6) occur several seconds after the epileptogenic discharges in the depth

recording in the depth showed that the left frontal spike activity preceded the right The simultaneous scalp recording showed only the bisynchronous bifrontal abnormalities, occurring several seconds after the onset of the seizure in the depth The level of the probe in which the abnormality arose is demonstrated (Fig 2) This is in the prefrontal area anterior to the motor strip, so the focus can be removed without a major neurological deficit

Roentgenologic control of the position of the electrodes is an intricate part of electroencephalography both for clinical and research purposes This report may stimulate further studies between electroencephalographers and neuroroentgenologists

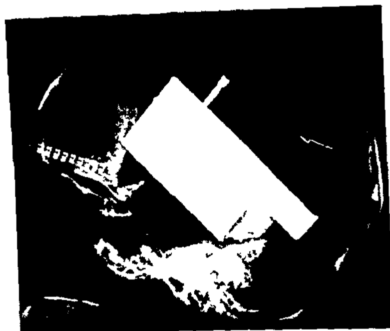


Fig 1 Phantom consisting of a dry skull filled with water a polyethylene bag tightly adherent to the skull retains the water and polyethylene tubes simulating vessels are visible in the posterior parietal area (arrow) (An iodine step wedge for the separate measurements of contrast and a line pair ruler for another measurement of resolution were used in the investigation)

contribution of each a skull phantom system was constructed in which it was possible to apply each of the variables independently while the others remained constant

Materials and Methods A phantom consisting of a dry skull immersed in water and surrounded by a thin polyethylene bag sealed at its mouth was utilized This phantom contained an iodine step wedge a wire grid commercial phantom and four capillary tubes which were taped to the side of the skull in the parietal area The e tubes contained 50 % Renografin 20 % Renografin 10 % Renografin and the last tube contained only water Water was used as a diluent in the other three tubes as well The inner diameter of these tubes was about 0 76 mm (0 030 inches)

Approximately 200 roentgenograms were obtained in a setting as close as possible to the serial filming of patients in the clinical situation using a Franklin

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RESOLUTION OF SMALL VESSELS IN ANGIOGRAPHY

Functional relations to focal spot size, kilovoltage, grid systems and secondary radiation

by

E RALPH HEINZ, JIMMY O FENN and NEAL CHANDLER

The resolution of small vessels in angiography is of critical importance in making a proper interpretation of the film For many years many centers have utilized relatively higher ranges of kilovoltage because of the limited heat loading capacity of the rotating anode tubes which limited the milliampere loading in a serial film examination Also, the time of the exposure could not be lengthened significantly because of patient movement In the past several years, better alloys, and higher speed rotation have created better heat loading characteristics in these tubes Theoretically, by increasing the mAs and reciprocally lowering the kilovoltage, the contrast of the different densities on the film would be improved, and resolution of smaller vessels would be greater, since resolution is a product of contrast and sharpness At the same time, the capacity for additional heat loading would allow the use of small focal spot size tubes which should theoretically reduce penumbra and therefore produce images of greater detail

For these reasons, it was decided to use the lowest possible kilovoltage, coupled with the smallest possible focal spot size tube, the former to increase contrast, and the latter to improve sharpness by reducing the penumbra To evaluate the

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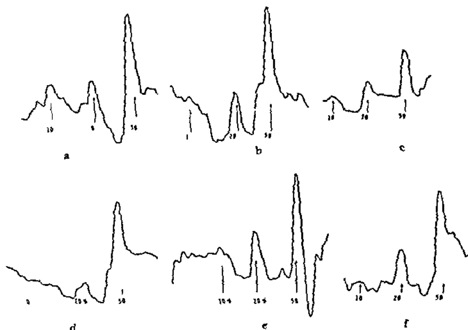


Fig 3 Microdensitometric curves obtained at 60 kV showing the effect of varying the effective focal spot size between 2 0 and 0 5 mm. There is no significant improvement in the resolution of the peaks at smaller focal spot sizes. The 10 % tube is seen just as well on the 2 0 mm focus size as on any of the others The small irregularities in the curves are related to the grid lines on the film The graphs have been elongated by a factor of ten along the abscissa. The focal spot size was as follows 2 0 mm (a) 1 5 mm (b) 1 0 mm (c) 0 8 mm(d) 0 6 mm (e) and 0 5 mm (f)

the films and it was of some interest that the third tube which contained 10 % Renografin was seen best on the film utilizing the largest focal spot size of all i e 2 0 mm This was confirmed on the microdensitometer reading

The resolution of the film with the water removed from the phantom was superior to all others demonstrating that despite appropriate grid systems secondary radiation is still one of the most significant contributors to loss of contrast and to unsharpness

It has been common practice both in the United States and in Europe to use higher kilovoltage ranges also in cerebral angiography Frequently but not always this has been dictated by the lack of suitable generators which prohibited significant mAs levels, as the time in serial filming could not be raised above 0 2 or 0 25 seconds without motion unsharpness The tubes were not of a heat loading capacity to accept larger mAs loads for serial exposures As both generators and tubes improved it seemed to us logical that if kilovoltage could be

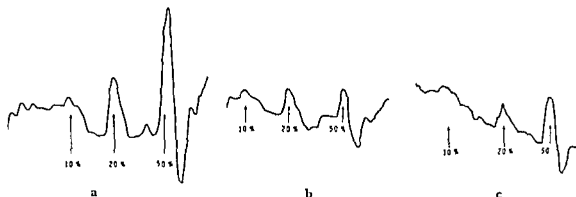


Fig 2 Microdensitometric curves showing resolution peaks produced by tubes containing 10 %, 20 % and 50 % concentrations of Renografin There is a sharp peak at 60 kV (a) as compared with the 75 kV (b) and 95 kV (c) ranges Contrast can be related to the height of the peak as compared with the base resolution can be related to the slope of the curve Focus size 0 6 mm

serial film changer Films were obtained at 95 kV through 60 kV and the focal spot sizes varied between 2 0 mm and 0 5 mm The focal spot size was varied by altering the anode film distance Three grid systems were utilized a 10 1 80 line linear grid, a crosshatch type with an 8 1 80 line grid, and a 12 to 1 linear grid with particular emphasis on eliminating secondary scatter in the higher kilovoltage range, as is done in clinical practice Standard screens were used throughout The radiographic tube was a Philips Super Rotalix high speed rotation 1 2 mm to 0 6 mm dual focal spot with 1 000 mA 3 phase generators

Finally, to assess the contribution of secondary scatter to sharpness, water was drained from the phantom and the film series was repeated The density of each roentgenogram was controlled as closely as possible by making three exposures at each focal spot size and each kilovoltage by changing the mAs Microdensitometric readings were made by scanning over the area of the four tubes The curves obtained were amplified by a factor of ten to make comparison easier

Results

There was a marked improvement in resolution as the kilovoltage was moved from 95 kV to 60 kV It is thought that this was a function of improved contrast

In this series, utilizing a progressively smaller focal spot, there was no significant improvement in resolution with focal spot sizes smaller than 1 0 mm The microdensitometric readings coincided closely with the subjective appraisal of

of the slope of the curve and could relate contrast to the height of the peak of the curve as compared to the base line

ROSSMAN (6) pointed out that each system must be evaluated independently from all other systems of resolution and that certain methods of evaluating the resolution such as the modulation transfer function, do not always apply uniformly to all resolution systems

Emphasis is therefore placed on the importance of lowering the kilovoltage range in clinical cerebral angiography and the relatively small contribution of small focal spot size tubes of less than 1 0 mm In systems utilizing biplane simultaneous exposures it would certainly appear that the decrease in Compton scatter would be of great help in decreasing the secondary fogging of the opposite plane as well Lower ratio grids could therefore be used which would allow a slight further reduction in the kilovoltage

It must be emphasized that these observations were made in relation to vessels which lie very close to the film in vessels which are at a greater distance from the film such as the midline cerebral vessels theoretically there should be more magnification and an increase in the unsharpness with larger focal spot size anodes For the purpose of this investigation it was arbitrarily decided to use surface vessels as the reference vessels

Although one could object to the method of creating smaller focal spot size sources by increasing the anode film distance, the relatively high ratio between the tube target and the target film distance 100 1 to approximately 300 1 suggests that relative changes in the tube target distance are of little importance when the ratio between the two distances is so large

It appears that unsharpness due to secondary radiation and to relatively large crystal size in the intensifying screens are the most significant bars to improved resolution in cerebral angiography at the present time

SUMMARY

An evaluation of the resolution of the small vessels in angiography using a skull phantom and contrast filled tubes was made and the changes in resolution related to varying kilovoltage and different focal spot sizes were recorded by microdensitometry Reduction of the kilovoltage to the 60—65 kV range appears to be the single most important contribution to improved resolution based on the increase in contrast This increased contrast is thought to be related to the relatively higher attenuation due to iodine as compared with water at this lower kV range

ZUSAMMENFASSUNG

Die Resolution bei Angiographie der kleinen Gefasse wurde mit Verwendung eines Schadelphantoms und kontrastgefullter Rohren studiert Die Resolutionsveranderungen bei Variation der Spannung und bei verschiedenen Brennfleckgrossen wurden mittels Mikrodensi

Fig. 1. The energy of the roentgen ray beam (monochromatic) is given along the abscissa. The greatest distinction (A) between the attenuation coefficient of I as compared with the attenuation coefficient of water falls just above the K edge of I. At higher energies (B) the difference between the attenuation coefficient of I and the attenuation coefficient of water is much reduced. (Courtesy of G. GRODSTEIN: X-ray attenuation coefficients from 10 keV to 100 MeV. NBS 1957 Circular 583.)

lowered the contrast would be correspondingly increased. Additionally, Compton scatter would be decreased and the resolution would be considerably improved (2, 3). Photo-electric absorption would be increased in the lower kilovoltage ranges and this would produce a short gray scale. This short gray scale means there is a greater difference in density between adjacent steps on a step wedge, and a corresponding sharper transitional line between the steps (1, 5). Absorption is a third power function of atomic number with photo-electric absorption and is only a linear function with Compton absorption. Also, photo electric absorption increases in $\frac{1}{E^{3}}$ relationship with decreasing kV (4).

Reduction of focal spot size also seemed a worthwhile goal based on theoretical distribution of penumbra. While this would be vastly more important in magnification work, it theoretically should also be important when the target film distance is fairly short, as in the usual cerebral angiographic examination (7). However, as subjective evaluation as well as more objective microdensitometric measurements indicate that under ordinary clinical circumstances, with present intensifying screens and films, there is no significant increase in the sharpness below the range of 2.0 mm to 1.0 mm focal spot size. This was checked by repeated scanning on films at both 60 kV and 75 kV ranges, and the findings were comparable. No attempt was made to assign numerical value to the curves obtained, although one could relate unsharpness quantitatively to the inclination

of the slope of the curve, and could relate contrast to the height of the peak of the curve as compared to the base line

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Although one could object to the method of creating smaller focal spot size sources by increasing the anode film distance the relatively high ratio *between* the tube target and the target film distance 100 1 to *approximately 300 1* suggests that relative changes in the tube target distance are of little *importance* when the ratio between the two distances is so large

It appears that unsharpness due to secondary radiation and to relatively large crystal size in the intensifying screens are the most significant bars to improved *resolution in* cerebral angiography at the present time

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tometrie ausgewertet. Eine Reduktion der Spannung bis auf dem 60—65 kV Bereich scheint den bedeutendsten einzelnen Beitrag zur Erhohung der Resolution zu leisten als Kontrasterhohung betrachtet. Diese Kontrastverbesserung durfte dem höheren Schwächungskoeffizienten des Jods im Verhaltnis zum Wasser zuzuschreiben sein.

RÉSUMÉ

Les auteurs ont étudie la resolution de petits vaisseaux en angiographie au moyen d'un fantome de tete et de tubes remplis de moyen de contraste. Ils ont mesuré par microdensitometrie les modifications en fonction des differentes tensions et des dimensions des divers foyers. La résolution est améliorée quand on utilise une tension comprise entre 60 et 65 kV. Cette augmentation du contraste dans le domaine des basses tensions parait due a l'attenuation relativement plus forte du rayonnement par l'iode par rapport a l'attenuation par l'eau.

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DENSITOMETRISCHE BESTIMMUNG DER HIRNDURCHBLUTUNG

von

F Heuck und U Piepgras

Die Kontrastdarstellung der Hirnstrombahn mit Hilfe der Serienangiographie hat neben der morphologischen und topographischen Darstellung der Hirngefäße *auch wesentliche Kenntnisse über die Durchblutung des Gehirns* vermittelt Eine Steigerung der Bildfrequenz ermöglichte Untersuchungen über Physiologie und Pathophysiologie des Hirnkreislaufes Die seit den ersten Untersuchungen von Moniz (1932) vorliegenden Befunde haben den Beginn der Injektion des Kontrastmittels in die A carotis und das Ende der venösen Füllung als Meßgrenzen gesetzt (Zusammenstellung s bei Krayenbühl und Yasargil 1965) Die bisher bekannten Durchschnittswerte der Kreislaufzeit des Gehirns schwanken zwischen einer und zwölf Sekunden (Scheurer und Wickbom 1952 Woringer und Mitarb 1956, Greitz 1956 Tönnis und Schiefer 1959, Schiefer 1961 Gilroy und Mitarb 1963 u a)

Die Mehrzahl der bisher mit klinisch radiologischen Methoden erarbeiteten Befunde über die Hirndurchblutung ergaben lediglich globale Meßwerte Selbst die modernen Untersuchungs*verfahren der Isotopendiagnostik* konnen nur größere Areale des Gehirns getrennt voneinander erfassen (Nylin 1955 Eichhorn 1959 Ingvar und Lassen *1961* Wilcke 1964/66) Es ist jedoch von großem klinischen Interesse, die Gewebsdurchblutung in verschiedenen um

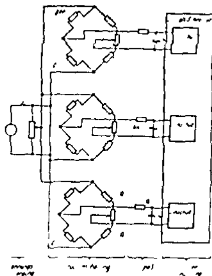


Abb. 1. Schema der Meßapparatur

schriebenen Hirnbezirken — auch am nicht narkotisierten Menschen — qualitativ und quantitativ messen zu können. Die Weiterentwicklung der Serienangiographie durch die Röntgenkinematographie mit hoher Bildfrequenz bietet neue Möglichkeiten zum Studium der im Röntgenbild nicht mehr sichtbaren Bereiche der Hirnstrombahn wie *Arteriolen, Kapillaren und Venolen*, also der Hirnperipherie, mit Hilfe densitometrischer Methoden. Im eigenen Arbeitskreis sind bereits densitometrische Untersuchungen der Kalksalzkonzentration im Skelett (HEUCK & SCHMIDT 1960) und des Luft-Wasser-Verhältnisses im Lungengewebe (VANSELOW & HEUCK 1964) durchgeführt worden. In enger Zusammenarbeit mit dem Institut für Angewandte Physik der Universität Kiel wurden die physikalisch-theoretischen Grundlagen einer Methode zur Messung der Durchblutung der Hirnperipherie erarbeitet (VANSELOW, HEUCK & PIEPGRAS 1967/68).

Prinzip der Methode. Das Prinzip der eigenen Meßmethode besteht darin, die während eines Kontrastmitteldurchflusses durch die Hirnstrombahn auftretenden Schwärzungsunterschiede des Einzelbildes einer Serienangiographie densitometrisch auszuwerten. Die entwickelte Meßapparatur arbeitet nach dem Prinzip der photometrischen Differenzmessung (räumliches Differenzprinzip). Als Meßköpfe werden Photowiderstände verwendet, die paarweise angeordnet sind und alle zwischen je 2 Meßpunkten auftretenden Helligkeitsdifferenzen in einen Fotostrom unterschiedlicher Spannung umwandeln. Das wichtigste Bau-

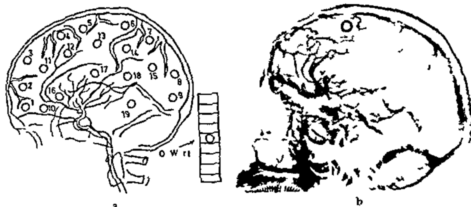


Abb 2 a) Skizze d r zur densitometrischen Registrierung von Kontrastm ttelverdunnungskur ven geeigneten Meßpunkte bei seitlicher Projektion der Hirnangiographie Der O Wert zur Subtraktion des Untergrundes kann auch auf einem Referenzsystem gewahlt werden b) Kombination von Subtraktionsaufnahmen der arteriellen und venosen Phase einer Angiographie zur Darstellung des Meßpunktes 4

element ist eine Bruckenschaltung welche einerseits 2 konstante Widerstande andererseits die beiden variablen Fotowiderstande fur die Messung enthalt (Abb 1) Zu einer Spannungsanderung kommt es in der Brucke aber nur dann wenn sich die Photowiderstande in unterschiedlichem Ausmaß andern *Diese Spannungsanderungen* werden uber ein Registriergerat (z B ein EGK Gerat herkömmlicher Bauart) in eine Meßkurve transformiert Erfolgt jedoch *eine* gleichsinnige Anderung beider Photowiderstande um denselben Betrag so bleibt eine Spannungsschwankung in der Bruckenschaltung und damit eine Änderung des *Kurvenverlaufs* aus Im Strahlengang des Bildes eines rontgenkinematographisch gewonnenen Filmes befinden sich 2 Photowiderstande Der eine Photowiderstand wird an der zu untersuchenden Hirnregion der andere an einem beliebigen nicht von Kontrastsubstanz durchflossenen Bezirk des Schadels angebracht Sind diese beiden Photowiderstande *Teile eines* Bruckenzweiges der Wheatstone schen Brucke so ergibt die Theorie eine Eliminierung aller Helligkeitsschwankungen (z B Schwankungen des Rohrenstromes der *Lichtintensitat* der Projektionslampe und anderer unerwunschter Storun en) Mit diesem einfachen Meßsystem werden alle nicht durch die Kontrastsubstanz hervorgerufenen Dichteanderungen im Bereich des Hirnschadels subtrahiert Über die theoretischen Grundlagen der Methode wurde an anderer Stelle ausfuhrlich berichtet (VANSELO i, HEUCK & PIEPGRAS 1967/68)

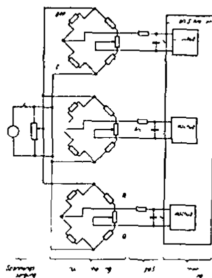


Abb. 1. Schema der Meßapparatur

schriebenen Hirnbezirken — auch am nicht narkotisierten Menschen — qualitativ und quantitativ messen zu können. Die Weiterentwicklung der Serienangiographie durch die Röntgenkinematographie mit hoher Bildfrequenz bietet neue Möglichkeiten zum Studium der im Röntgenbild nicht mehr sichtbaren Bereiche der Hirnstrombahn wie Arteriolen, Kapillaren und Venolen, also der Hirnperipherie, mit Hilfe densitometrischer Methoden. Im eigenen Arbeitskreis sind bereits densitometrische Untersuchungen der Kalksalzkonzentration im Skelett (HEUCK & SCHMIDT 1960) und des Luft-Wasser-Verhältnisses im Lungengewebe (VANSELOW & HEUCK 1964) durchgeführt worden. In enger Zusammenarbeit mit dem Institut für Angewandte Physik der Universität Kiel wurden die physikalisch-theoretischen Grundlagen einer Methode zur Messung der Durchblutung der Hirnperipherie erarbeitet (VANSELOW, HEUCK & PIEPGRAS 1967/68).

Prinzip der Methode. Das Prinzip der eigenen Meßmethode besteht darin, die während eines Kontrastmitteldurchflusses durch die Hirnstrombahn auftretenden Schwärzungsunterschiede des Einzelbildes einer Serienangiographie densitometrisch auszuwerten. Die entwickelte Meßapparatur arbeitet nach dem Prinzip der photometrischen Differenzmessung (räumliches Differenzprinzip). Als Meßköpfe werden Photowiderstände verwendet, die paarweise angeordnet sind und alle zwischen je 2 Meßpunkten auftretenden Helligkeitsdifferenzen in einen Fotostrom unterschiedlicher Spannung umwandeln. Das wichtigste Bau

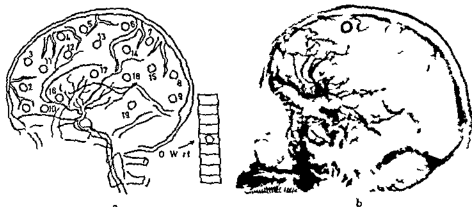


Abb. 2 a) Skizze der zur densitometrischen Registrierung von Kontrastmittelverdünnungskurven geeigneten Meßpunkte bei seitlicher Projektion der Hirnangiographie. Der O-Wert zur Subtraktion des Untergrundes kann auch auf einem Referenzsystem gewählt werden. b) Kombination von Subtraktionsaufnahmen der arteriellen und venösen Phase einer Angiographie zur Darstellung des Meßpunktes 4

element ist eine Brückenschaltung, welche einerseits 2 konstante Widerstände, andererseits die beiden variablen Fotowiderstände für die Messung enthält (Abb. 1). Zu einer Spannungsänderung kommt es in der Brücke aber nur dann, wenn sich die Photowiderstände in unterschiedlichem Ausmaß ändern. Diese Spannungsänderungen werden über ein Registriergerät (z. B. ein EGK-Gerät herkömmlicher Bauart) in eine Meßkurve transformiert. Erfolgt jedoch eine gleichsinnige Änderung beider Photowiderstände um denselben Betrag, so bleibt eine Spannungsschwankung in der Brückenschaltung und damit eine Änderung des Kurvenverlaufs aus. Im Strahlengang des Bildes eines röntgenkinematographisch gewonnenen Filmes befinden sich 2 Photowiderstände. Der eine Photowiderstand wird an der zu untersuchenden Hirnregion, der andere an einem beliebigen, nicht von Kontrastsubstanz durchflossenen Bezirk des Schädels angebracht. Sind diese beiden Photowiderstände Teile eines Brückenzweiges der Wheatstone'schen Brücke, so ergibt die Theorie eine Eliminierung aller Helligkeitsschwankungen (z. B. Schwankungen des Röhrenstromes, der Lichtintensität der Projektionslampe und anderer unerwünschter Störungen). Mit diesem einfachen Meßsystem werden alle nicht durch die Kontrastsubstanz hervorgerufenen Dichteänderungen im Bereich des Hirnschädels subtrahiert. Über die theoretischen Grundlagen der Methode wurde an anderer Stelle ausführlich berichtet (VANSELOW, HELCK & PIEPGRAS 1967/68).

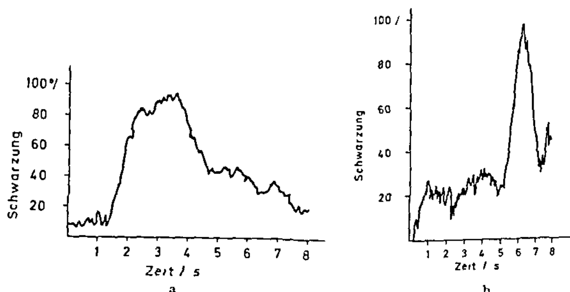


Abb 3 a) Kontrastmittelverdunnungskurve des beschriebenen Modellversuches mit einem Gummiballon b) Densitometrisch gewonnene Kontrastmittelverdunnungskurve aus dem Parietalbereich

Die gleichzeitige Verwendung eines Referenzsystems erlaubt die Messung der Kontrastmittelkonzentration in jedem beliebigen Hirnabschnitt, so daß Kontrastmittelverdunnungskurven verschiedener Hirnbezirke zueinander in Beziehung gesetzt werden konnen *Es ist moglich, das Blutstromvolumen im Hirngewebe* rechnerisch zu bestimmen

Die angiodensitometrie des Hirnkreislaufes wurde in Einzelpunktmessungen an Serienangiogrammen (AOT-Bildwechsler, 4 Bilder/Sekunde und Odelca Schirmbildkamera, Rapidix Kasette 5 Bilder/Sekunde) und durch kontinuierliche Registrierung der Bildserie von Rontgenkinofilmen (Cinelix mit Askania Kamera, 45 Bilder/Sekunde) vorgenommen

Die Meßpunkte sollten nach Moglichkeit so lokalisiert sein, daß eine Überlagerung durch großere Gefaßaste (Arterien oder Venen) ausgeschlossen ist (Abb 2) Aus methodischen Grunden ist es verstandlich, daß kein gleichmaßiger, kontinuierlicher Kurvenverlauf resultiert

Die Reproduzierbarkeit und Schwankungsbreite der Meßmethode bei wiederholten Messungen *wurde an einem Modellversuch getestet* Wahrend der Injektion einer Kontrastsubstanz in einen mit Wasser gefullten Gummiballon kommt es zu einem meßbaren Anstieg der Kontrastkonzentration in Richtung des Injektionsstrahles Die densitometrisch registrierte Kurve laßt danach deutlich die Verdunnung und Verteilung des Kontrastmittels erkennen Durch Vor- und Ruckspulen des Filmes ist die Kurve exakt zu reproduzieren (Abb 3a)

Die Meßempfindlichkeit des Systems ist so groß, daß bereits eine kleine Kontrastmittelmenge von 3 ml als Bolus in die A. carotis interna injiziert ausreicht um die periphere Hirndurchblutung röntgenkinematographisch messen zu können Bei 15 Angiokinematographien wurde die Kontrastanflutung die Verdünnung, und der Kontrastabstrom im Bereich des Parietalhirns und des Stirnhirns gemessen Die Untersuchungen wurden am nicht narkotisierten Menschen durchgeführt

In Abb 36 ist als Beispiel eine im Parietalbereich densitometrisch gewonnene Kontrastmittelverdünnungskurve dargestellt Es ist ein deutlich reproduzierbarer Anstieg der Kontrastdichte innerhalb von einer Sekunde bis zu einem Maximum festzustellen Ein Plateau hat sich nicht eingestellt Es treten geringfügige Dichteschwankungen und dann ein Abfall der Kontrastmittelkonzentration innerhalb von 1 2 Sekunden in Erscheinung Einige Desitometerkurven zeigten im Bereich des Absinkens der Kontrastkonzentration im Hirngewebe einen nochmaligen kurzfristigen Anstieg der Konzentration innerhalb von 0 5 Sekunden, doch erreichte dieser Anstieg nur etwa den dritten Teil der primären Kontrastdichte Diese Nachschwankung ist auffallend und soll weiter analysiert werden Sie ist möglicherweise durch eine größere, sich füllende Vene im Gebiet des Meßareals bedingt

Bei Verwendung mehrerer Meßzellenpaare kann die fortlaufende Registrierung der Kontrastmittelverdünnung aus einem Röntgenkinofilm oder direkt vom Fernsehmonitor eine gleichzeitige Analyse des Blutflusses in den verschiedensten Hirnarealen ermöglichen Aus dem Verlauf der röntgendensitometrisch gewonnenen Kontrastmittelverdünnungskurven können folgende Informationen gewonnen werden

1 Das Blutstromvolumen in den großen zuführenden Gefäßen (Arterien und Venen)
2 Die Dauer der arteriellen Füllungsphase der Hirnstrombahn (Anflutungszeit)
3 Dauer und Intensität der Gewebsdurchblutung (Gewebsphase)
4 Die Dauer des Abströmens der Kontrastsubstanz aus dem untersuchten Gewebsareal (Abstromzeit)
5 Nachweis einer protrahierten Kontrastanreicherung des Gewebes infolge Störung der Kapillarpermeabilität

Die bisher mit der densitometrischen Differenzmessung gewonnenen Untersuchungsergebnisse sind gut reproduzierbar und berechtigen zu der Hoffnung daß diese neue Methode auch zu einer quantitativen Messung der Hirndurchblutung in umschriebenen Gewebsarealen weiter entwickelt werden kann Hier

durch wäre eine exakte Objektivierung von Durchblutungsstörungen des Gehirns möglich Der Verlauf der röntgendensitometrisch gewonnen Kontrastmittelverdünnungskurven gibt über die Art der Durchblutungsstörung Auskunft, die neue Meßmethode stellt eine wesentliche Bereicherung unserer bisherigen diagnostischen Möglichkeiten dar

ZUSAMMENFASSUNG

Eine neue Methode der röntgendensitometrischen Differenzmessung zur Analyse der Hirndurchblutung mit Hilfe der Serienangiographie und der Angiokinematographie wird vorgelegt Die Reproduzierbarkeit der Methode wird an Modellversuchen bewiesen Die Meßergebnisse werden an Beispielen erläutert Auf den Informationswert und die diagnostischen Möglichkeiten einer subtilen Analyse des Hirnkreislaufes mit Hilfe der röntgendensitometrischen Differenzmessung wird hingewiesen

SUMMARY

A new method for roentgendensitometric differential analysis of the cerebral circulation by means of serial angiography and cineroentgenography is described Model experiments have confirmed the reproducibility of the method and measurement results are elucidated by examples The method permits valuable information to be obtained and the diagnostic possibilities offered by a detailed analysis of the cerebral circulation by means of a roentgen densitometric analysis are emphasized

RÉSUMÉ

Les auteurs présentent une nouvelle méthode radiodensitométrique de mesure différentielle de la circulation cérébrale en angiographie en série et en angiocinematographie Ils ont vérifié la reproductibilité de cette méthode par des expérimentations sur des modeles Ils donnent des exemples des résultats de ces mesures Ils insistent sur l intérêt des informations obtenues et sur les possibilités diagnostiques d une analyse fine de la circulation cerébrale au moyen de mesures différentielles roentgendensitométriques

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SERVICE DE NEURORADIOLOGIE (DIRECTEUR PROF. G. RUGGIERO), OSPEDALE MAGGIORE, BOLOGNA, ITALIE

MÉTHODE RADIOGRAPHIQUE POUR MESURER LES MOUVEMENTS DES STRUCTURES ENDOCRANIENNES

par

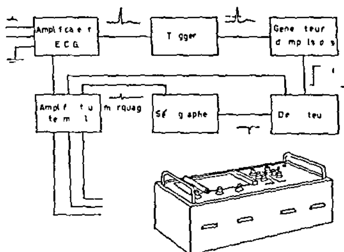
G. RUGGIERO, C. TREVISAN et A. MANNO

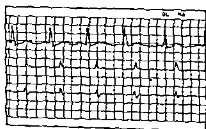
Des mouvements éventuels des structures nerveuses à l'intérieur du crâne peuvent être donnés par les battements artériels ou par le déplacement par gravitation. Pour les déplacements par gravitation on peut utiliser des repérages osseux et des repérages ventriculaires ou cisternaux. Pour les repérages ventriculaires il faudra évidemment employer deux contrastes, opaque et gazeux. Pour les déplacements dûs aux battements artériels, auxquels est consacré ce travail, nous proposons une méthode fondée sur l'association de la sériographie rapide et de la soustraction d'image. On soustrait, l'une de l'autre, des radiographies faites à différents moments de la révolution cardiaque.

Comme appareillage (Fig. 1), il s'agit d'un enregistreur à écriture directe à trois canaux avec un amplificateur qui permet d'enregistrer l'ECG, la synchronisation de l'angiographie avec un point donné de l'activité cardiaque et un artefact correspondant au passage des rayons. Pour la synchronisation de l'angiographie avec l'ECG, on a construit un générateur d'impulsions et une ligne de retard variable de façon linéaire à l'aide d'un point de commande particulier.

Il est donc possible de faire correspondre une impulsion à un point quelconque de l'activité cardiaque et par conséquent d'avoir une série de radiographies qui correspondent toutes à ce même point. En variant ce point, et en comparant entre elles les radiographies de la première série avec celles de la seconde, on comparera les données angiographiques ou encéphalographiques correspondant à différentes phases de la révolution cardiaque.

Cette méthode, qui aurait l'avantage de choisir le moment de la révolution cardiaque où faire la radiographie, présente deux désavantages : (1) il faut pratiquer au moins deux séries de radiographies et, en cas d'angiographie, deux injections de contraste, (2) avec le sériographe actuellement à notre disposition,





SIGNAL ECG

SYNCHRONISATION

PASSAGE DES RAYONS

Fig. 1 Schéma de l'appareillage utilisé pour l'accouplement ECG sériographe et pour le marquage des radiographies

Fig. 2 Graphique avec ECG (en bas) et signal du passage des rayons (en haut)

il est impossible d'obtenir un retard constant entre le signal envoyé et le moment réel du passage des rayons

Pour éviter ces inconvénients nous avons actuellement recours à une méthode plus simple nous enregistrons l'*électrocardiogramme* et l'artefact dû au passage des rayons pendant une sériographie *suffisamment* rapide pour analyser con

SERVICE DE NEURORADIOLOGIE (DIRECTEUR PROF G RUGGIERO), OSPEDALE MAGGIORE, BOLOGNA, ITALIE

METHODE RADIOGRAPHIQUE POUR MESURER LES MOUVEMENTS DES STRUCTURES ENDOCRANIENNES

par

G Ruggiero, C Trevisan et A Manno

Des mouvements eventuels des structures nerveuses a l interieur du crane peuvent être donnes par les battements arteriels ou par le deplacement par gravitation Pour les deplacements par gravitation on peut utiliser des reperages osseux et des reperages ventriculaires ou cisternaux Pour les reperages ventriculaires il faudra evidemment employer deux contrastes, opaque et gazeux Pour les deplacements dûs aux battements arteriels, auxquels est consacre ce travail, nous proposons une methode fondee sur l association de la seriographie rapide et de la soustraction d image On soustrait, l une de l autre, des radiographies faites a differents moments de la revolution cardiaque

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Il est donc possible de faire correspondre une impulsion a un point quelconque de l activite cardiaque et par consequent d avoir une serie de radiographies qui correspondent toutes a ce même point En variant ce point, et en comparant entre elles les radiographies de la premiere serie avec celles de la seconde, on comparera les donnees angiographiques ou encephalographiques correspondant a differentes phases de la revolution cardiaque

Cette methode, qui aurait l avantage de choisir le moment de la revolution cardiaque ou faire la radiographie, presente deux desavantages (1) il faut pratiquer au moins deux series de radiographies et, en cas d angiographie, deux injections de contraste, (2) avec le seriographe actuellement a notre disposition,

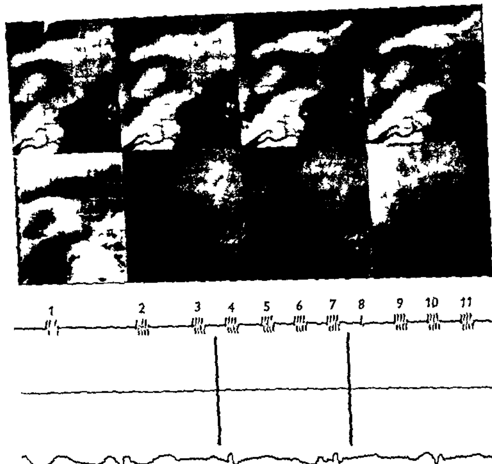


Fig 4 Mensuration radiographique des mouvements de l aqueduc et du quatrième ventricule Premiere rangee quatre radiographies s etalant sur la revolution cardiaque indiquee par l raphique (1) Du premier cliche on a fait le masque apparaissant au d ssous La second rangee montre les soustractions des images de la rangee superieure On n observe pas de mou ements des structures l aqueduc et le quatrième ventricule apparaissent complètement effacés

les *mouvements* du niveau hydroaerique dans le troisieme ventricule et dans les ventricules lateraux Ceux-ci semblent se *comporter de facon* opposee quand l image des ventricules lateraux « s allonge » celle du troisieme ventricule « se raccourcit » Apparemment le contraire ne *se verifie pas* et l image des ventricules lateraux ne se raccourcit pas pendant l allongement du troisieme ventricule Ceci est probablement du a *une raison* technique La quantite d air qui se trouve dans les deux ventricules est en effet tres importante et le contraste est trop accentue pour obtenir une *soustraction leur* image ne disparait pas

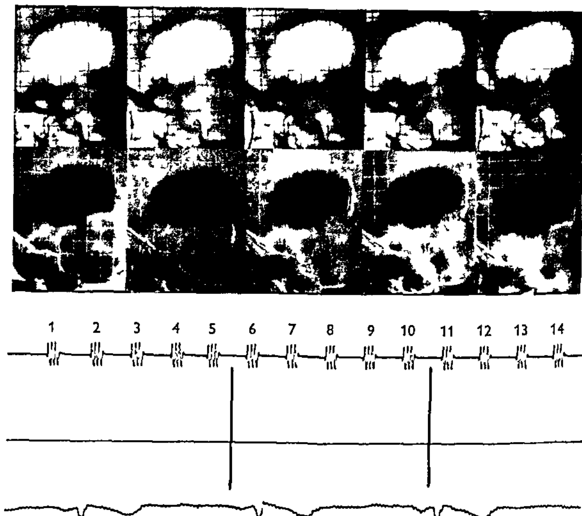


Fig 3 Mensuration radiographique des mouvements du troisième ventricule Graphique avec ECG et passage des rayons En haut cinq radiographies d une serie de 16 qui s étalent sur une revolution cardiaque Le premier cliche a *servi à faire* le masque qu *on voit en* dessous Ce masque a ete utilise pour la soustraction de tous les autres cliches En bas se trouvent les soustractions des cliches de la rangee superieure Le mouvement du niveau hydro aérique dans le troisième ventricule est evident quand ce niveau se déplace vers l avant l amplitude de son mouvement est marquee par l ombre noire quand il se deplace vers l arrière par l ombre blanche La grille a ete utilisee pour obtenir une superposition parfaite

venablement les modifications de la circulation cerebrale eventuellement observees dans les differentes phases de la revolution cardiaque (Fig 2) Nous faisons generalement quatre radiographies par seconde un rythme plus rapide compliquerait la technique de soustraction a cause des vibrations de l angiographe, il serait difficile d obtenir des cliches parfaitement superposables Il y aurait encore beaucoup d autres questions techniques, elles sortent des limities de ce premier travail

Un exemple d utilisation de cette technique est donne (Fig 3) On y remarque

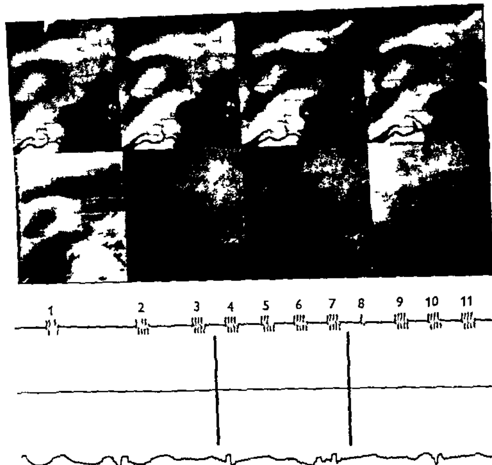


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les mouvements du niveau hydroaerique dans le troisieme ventricule et dans les ventricules lateraux Ceux ci semblent se comporter de façon opposee quand l image des ventricules lateraux « s allonge » celle du troisieme ventricule « se raccourcit » Apparemment le contraire ne se verifie pas et l image des ventricules lateraux ne se raccourcit pas pendant l allongement du troisieme ventricule Ceci est probablement du a une raison technique La quantite d air qui se trouve dans les deux ventricules est en effet tres importante et le contraste est trop accentue pour obtenir une soustraction leur image ne disparait pas,

reste blanche et il est impossible de remarquer le blanc sur le blanc. Sur les figures, évidemment, le blanc et le noir apparaissent inversés.

Ce cas, assez spectaculaire, est le seul de notre brève série dans lequel nous avons observé des mouvements aussi importants (en additionnant le blanc et le noir cela fait presque 0,5 cm). Deux autres cas ont montré de petites variations. Dans deux cas nous avons étudié la partie sous-tentorielle du S. V. qui ne semble pas bouger (Fig. 4).

Conclusions

1. Il existe des déplacements des niveaux hydroaériques pendant la révolution cardiaque, et la méthode décrite permet de les démontrer radiographiquement.

2. En améliorant la technique (ce que nous faisons actuellement) il devrait être possible de matérialiser avec précision ces mouvements.

3. La structure que l'on étudie le plus facilement est le troisième ventricule.

4. Il semble que les mouvements soient plus évidents dans les cas de dilatation ventriculaire et quand il existe une brèche osseuse, comme dans notre premier cas où il y avait une crâniotomie de la fosse postérieure.

L'étude des mouvements ventriculaires en projection antéro-postérieure et celle des mouvements des artères sont actuellement en cours. Nous espérons ainsi pouvoir répondre à différentes questions : la pulsation du cerveau est-elle influencée par l'air et dans quelles conditions, normales ou pathologiques, est-elle la plus importante ? Est-ce seulement le liquide céphalo-rachidien qui « bat » ou bien le parenchyme cérébral bat-il aussi ?

RÉSUMÉ

Les mouvements du cerveau, ses pulsations et les battements des vaisseaux peuvent être étudiés en comparant des images encéphalographiques et angiographiques en différentes positions et à différentes phases de la révolution cardiaque. L'analyse se fait sur des soustractions et le passage des rayons peut être commandé par le rythme cardiaque.

SUMMARY

The movements and pulsations of the brain and its vessels can be studied by comparing encephalographic and angiographic images in different projections and in different phases of the cardiac cycle. Subtraction analysis was employed and the passage of the rays could be controlled by the rhythm of the cardiac cycle.

ZUSAMMENFASSUNG

Die Bewegungen und die Pulsationen des Gehirns und dessen Gefässe können bei Vergleich der encephalographischen und angiographischen Bilder in verschiedenen Projektionen und verschiedenen Phasen der Herzrevolution studiert werden. Die Analyse wurde mit Subtraktion durchgeführt und der Strahlengang durch den Rhythmus der Herzrevolution kontrolliert.

FROM THE DEPARTMENT OF RADIOLOGY COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY, AND THE NEUROLOGICAL INSTITUTE COLUMBIA PRESBYTERIAN MEDICAL CENTER NEW YORK U S A

EVALUATION OF THE VACUUM CASSETTE IN NEURORADIOLOGIC DIAGNOSIS

by

MICHAEL S TENNER and ERNEST H WOOD

A renewed interest in the applications of a vacuum cassette has arisen since the advent of commercially available equipment that rapidly evacuates the space between film and screen (AMPLATZ 1963) Intimate screen film contact is ensured by placing a wafer thin cassette in a plastic envelope from which air is exhausted under approximately 500 mm mercury pressure The envelope is heat sealed at the time of evacuation

In order to evaluate the vacuum cassette a series of experiments were made encompassing a spectrum of grid screen, film and radiant intensity factors Comparison of the physical resolution obtained in the resultant roentgenogram was made by visual inspection and more precisely by measurement utilizing a thin slit aperture of a sensitive densitometer (HILAL 1966) These tests revealed that an advantage could be gained in image quality with the use of the vacuum cassette even over the best available standard cassette equipment

The percentage gain of the vacuum cassette under different conditions is re

This work was in part supported by a Special Fellowship in Neuroradiology (2F11 NB 1415-02)

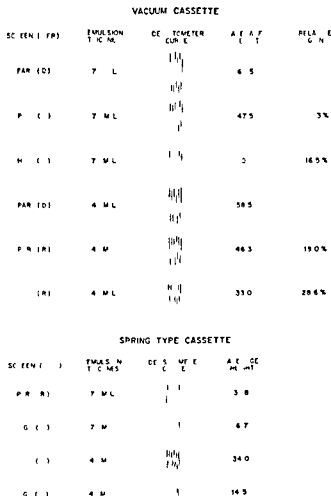


Fig 1 Evaluation of improvement gained with the vacuum cassette under different conditions The average improvement in contrast using film of normal thickness is 22 %

corded in Fig 1 A scaled down replica of the densitometer curve is adjacent to each set of conditions that are compared The height of the curve increases as the contrast between the grid lines increases The measurement of the curve height was made directly from a recording graph Each unit had a physical measurement of 2 millimeters The relative gain is calculated by assigning to the highest curve a value of 100 and relating the remaining curves to this value What is perhaps of greatest interest is the increase in sharpness obtained utilizing the par speed screen with the usual thickness of the film The average gain was found to be approximately 22 %

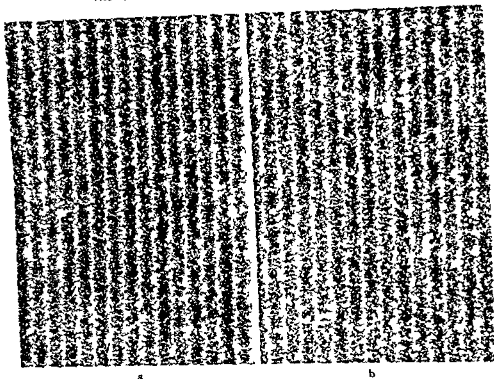
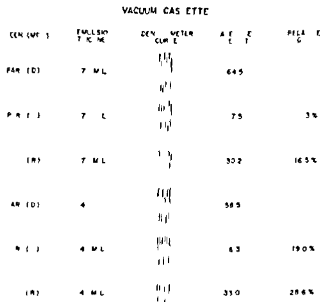


Fig 2 Roentgenograms of a grid obtained with par speed screens The sharper appearance of the juncture between the ridges and valleys of the grid lines characterizes the improvement gained with the vacuum cassette (a) over a spring-closed cassette with new intensifying screens (b)

In order to visually appreciate this improvement *in sharpness* a photographic enlargement of grid lines radiographed with par speed and high speed screens is shown in Figs *2 and 3*

Comparative roentgenograms were then obtained in the diagnostic evaluation of patient material in the parameters of *conventional skull* radiography tomography encephalography *and myelography The* improved detail is especially appreciated upon inspection of osseous *structures* with thin cortical borders A particularly noticeable gain in definition was achieved at encephalography when the surfaces of air and bone are in close relationship and at the interfaces between air and soft tissue

Examples of clinical material are shown to illustrate the increased information yielded with the use of the vacuum cassette (Figs 4 *and* 5) The cassette is not



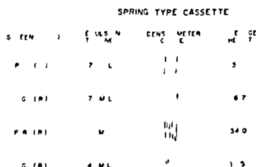


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Fig 4 Roentgenograms of an elderly patient with a demineralized sella turcica The fact that the cortical borders of the dorsum sellae are intact is appreciated with the vacuum cassette (a) but is less evident in a conventional roentgenogram (b) The additional information yielded with the vacuum cassette permits better evaluation of demineralization and its differentiation from eros on

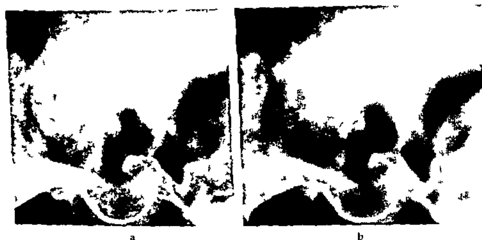


Fig 5 Comparati e lateral roentgenograms dur ng encephalography with the vacuum cass tte (a) and with a spring closed cassette (b) The common difficulty in assessing the optic and infu d bular recesses of the third ventricle particularly when there is superimposed cisternal i has been greatly lessened with the use of the vacuum cassette There is also sharp r de lineat on of the infer or border of the lateral recess of the temporal horn than in a conventional roentgenogram

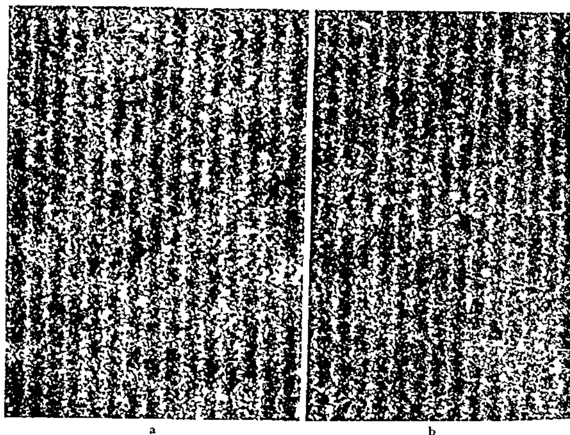


Fig 3 Roentgenograms of a grid utilizing high speed screens The vacuum cassette (a) gives resolution superior to a standard cassette (b) but definition is not as good as seen in fig 2

used for angiography at our institution because of the logistic problem involved *Several hundred exposures are made daily in the angiographic section and the* increased time that would be necessary to prepare the cassettes makes their use prohibitive However, the advantage in angiography that would accrue from having the problem of screen film contact solved is obvious If, in the future the preparation of the vacuum cassette becomes fully automated, its use in angiography will be more feasible

POSITIVE CONTRAST DEMONSTRATION OF A CEREBROSPINAL FLUID FISTULA THROUGH THE FUNDUS OF THE INTERNAL AUDITORY MEATUS

by

B. KAUFMAN, W. M. JORDAN and L. L. PRATT

Recurrent meningitis in children is a serious problem. In some cases it is associated with a radiographically demonstrable congenital malformation of the bony labyrinth. Otorrhea or rhinorrhea, or both, may be present. Such a case in which the exact site of a fistulous tract through the internal auditory meatus was demonstrated by cisternography of the posterior fossa, using a positive contrast medium, is described in the present paper. The pertinent bony anatomy of the fundus of the internal auditory meatus is discussed and illustrated.

Case report

A male infant, at the age of 15 months, developed his first bout of meningitis and subsequently developed three more in a 3 year period. Numerous attacks of right otitis media occurred, some associated with bouts of meningitis.

Radiologic changes in the right mastoid were noted and mastoidectomy was carried out. Clear cerebrospinal fluid was found in the mastoid cells, and careful examination of the middle ear cavity disclosed a cerebrospinal fluid leak in its medial wall. The ossicles were not removed and the fistula was not closed.

THE DEPARTMENT OF RADIOLOGY (DIRECTOR H. L. FRIEDELL) AND THE DEPARTMENT OF SURGERY, DIVISION OF OTOLARYNGOLOGY (DIRECTOR W. H. MALONEY), THE UNIVERSITY HOSPITALS OF CLEVELAND, CASE WESTERN RESERVE UNIVERSITY, CLEVELAND, OHIO, U.S.A.

SUMMARY

Considerable experience with the vacuum cassette has been accumulated and the clinical applications of the cassette have been formulated. A tabulation of the areas of practical applicability is given and the superior roentgenograms obtained in these areas are illustrated.

ZUSAMMENFASSUNG

Nach umfassenden Erfahrungen mit der Vakuum-Kassette ist jetzt die klinische Anwendung dieser Kassette spezifiziert worden. Eine Aufstellung der praktischen Anwendungsgebiete wird gegeben und die Überlegenheit der Röntgenogramme mit dieser Kassette wird illustriert.

RÉSUMÉ

Les auteurs ont acquis une expérience considérable de la cassette à vide et formulent ses applications cliniques. Ils donnent un tableau de ses applications pratiques et illustrent par des exemples la supériorité des radiographies ainsi obtenues.

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— Human carotid artery flow determination using a radiographic technique. Invest. Radiol. 1 (1966) 113.



Fig 9 P a projections of the petrous bones showing the congenital anomaly of the right bony labyrinth The e tibule and the cochlear region are superimposed and more clearly seen than on the left side secondary to the presumed absence of the modiolus and base of the cochlea (arrow) the lateral semicircular canal s widened (In other projections the vestibule was seen to be widened and the fundus of the internal auditory meatus was not identified)

he v ould have suspected an abnormality if he had not been forewarned Indigo carmine injected into the internal auditory meatus appeared in the external auditory canal The internal auditory meatus was closed with a plug of muscle and fascia Postoperatively there was no otorrhea and the child has remained well from 1961 up the present a period of six years

Discussion

Our demonstration of the exact route of egress of the cerebrospinal fluid from the internal auditory canal to the inner and middle ear confirms what others have suspected in their cases of recurrent meningitis with a congenital mal formation of the inner ear (DANDY 1944 NENZELIUS 1951, PRECECHTEL 1954 SKOLNIK & FERRER 1959 SPITZ et coll 1961 ROCKETT et coll 1964)

The original article by NENZELIUS in 1951 should be consulted for a com prehensive discussion of the developmental anatomy of the membranous and bony labyrinth and the probable routes of cerebrospinal fluid flow through the internal ear in cases of spontaneous otorrhea There are striking similarities be tween the cases described by him and the case presented in this paper both from the clinical standpoint and the surgical findings He assumed in his case that the route of egress of cerebrospinal fluid was through the internal auditory canal into the perilymphatic space of the vestibule and then a fistula in the medial wall of the tympanic cavity occurred when the tissue in this region possibly abnormal in development could not resist the transmitted intracranial cere brospinal fluid pressures

When there is a malformation of the bony labyrinth in a patient with recurrent



Fig 1 Decubitus view (slightly oblique) of the right petrous pyramid Pantopaque filling the cerebellopontine cistern (—→) and the Pantopaque cerebrospinal fluid level indicating the position of the head relative to the horizontal The internal auditory canal (+—→) is seen in its entire length communicating abnormally with the vestibule part of the cochlea and the middle ear cavity (⟼) the eustachian tube (white —→) is filled with contrast medium the medium also passes to the attic (o→) and to the mastoid cells (o→) The contrast filling of the external auditory meatus through the fistula from the mastoid cells is not particularly good in this view

Right middle fossa craniotomy was made to repair the cerebrospinal fluid fistula through a suspected persistent petro-squamal suture (CAFFEY 1961 and PRECECHTEL 1954) The procedure was not successful and in addition to cerebrospinal fluid rhinorrhea the patient developed a frank cerebrospinal fluid otorrhea with an intact tympanic membrane

Ventriculography with Pantopaque (iodophenylundecylate) was normal Two milliliters of Pantopaque were introduced into the lumbar subarachnoid space and maneuvered selectively into the right cerebellopontine cistern A series of maneuvers were performed to place the Pantopaque in contact with all parts of the posterior aspect of the petrous bone Each position was maintained for a minimum of 10 minutes to increase the likelihood of passage of the Pantopaque through a very small hole Functionally the cerebellopontine cistern acts as a closed space in most patients and the various positions can be maintained

A fistulous tract arising from the region of the fundus of the internal auditory canal was demonstrated (Fig 1) Pantopaque could be followed from the fundus to the inner and middle ear and from there to the eustachian tube and to the attic From the attic Pantopaque filled part of the mastoid cells explaining the presence of cerebrospinal fluid in the cells at the time of the initial surgical procedure A fistulous tract coursed from the mastoid cells to the external auditory canal which readily explains the cerebrospinal fluid otorrhea in the presence of an intact tympanic membrane Otorrhea in this case followed upon mastoidectomy and may have been iatrogenic in origin

The third surgical procedure was a posterior fossa craniotomy revealing an internal auditory canal considered slightly larger than normal The neurosurgeon doubted whether



Fig 2 P a projections of the petrous bones showing the congenital anomaly of the right bony labyrinth The vestibul and the cochlear region are superimposed and more clearly seen than on the left s de secondary to th presumed absence of the modiolus and base of the cochlea (arrow) the late al semic rcular canal is widened (In other projections the vestibule was seen to be widened and the fundus of the internal auditory meatus was not identified)

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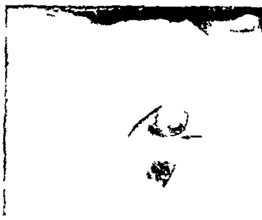


Fig 3 Posterior aspect of the left petrous bone in upright position The petrous apex is seen in the upper right corner the falciform (transverse) crest (arrow) separates the internal auditory canal in two compartments

meningitis, the likelihood of a cerebrospinal fluid fistula being present is very good When otorrhea or rhinorrhea is present in association with a radiographically demonstrable malformation of the bony labyrinth, the fistulous site is in all probability in the malformed internal ear The malformation of the bony labyrinth is in response to the malformation of the membranous labyrinth (NENZELIUS) If there is an abnormal communication from the subarachnoid space to the inner ear, repeated middle ear and mastoid infections might very well hasten rupture of the bony and membranous labyrinth resulting in cerebrospinal fluid rhinorrhea otorrhea, or both It is interesting that the time of onset of meningitis occurs not infrequently in the second year of life, but the cases reported do represent a selected group (NENZELIUS, SPITZ et coll 1961, ROCKETT et coll 1964)

Areas of decreased resistance in the dura mater supposedly occur normally in the cribriform plate region and in the internal auditory meatus (PRECECHTEL) Trauma has been considered a major etiologic factor in producing a weakened dura mater with subsequent development of a cerebrospinal fluid fistula many years later These post traumatic cases occur and are well documented A persistent petro-squamous suture as a predisposing factor in recurrent meningitis *has not been so well documented* (PRECECHTEL and CAFFEY 1961) It was the concept of the persistent petro squamous suture and failure to recognize the congenital defect of the bony labyrinth (Fig 2) which led to the unsuccessful exploration of the right middle fossa for a fistula through a persistent suture Recurrent meningitis, in the infant particularly, but also in the adult necessitates a search for a dural defect (ROCKETT et coll 1964, WHITECAR et coll 1966)

The most likely sites of congenital dehiscences between the subarachnoid space and the inner and middle ear are the internal auditory meatus the cochlear aqueduct, the aqueduct of the vestibule, and the subarcuate fossa (NENZELIUS



Fig 4 Posterior aspect of the left petrous bone with the bony canal widened to expose the fundus Foramen for facial nerve and nervus intermedius (—→) superior vestibular area (+→) with many small foramina the spiral cribriform tract (→) locates the base of the cochlea (not shown is the orifice of the canal of the modiolus) The inferior vestibular area (+→) is also composed of numerous foramina while the foramen singulare (○→) is a distinct foramen the external opening of the cochlear aqueduct (>→) the aqueductus vestibuli (>>→) and the fossa subarcuata (>>>→) are three other potential sites of cerebrospinal fluid fistulae

Precechtel Skolnik & Ferrer) These potential sites of cerebrospinal fluid fistulae all occur on the posterior aspect of the petrous bone with the exception of the cochlear aqueduct located on the inferior surface with present day techniques of cisternography of the posterior fossa using positive contrast medium they are all capable of being evaluated The fistulous tract associated with the fundus of the internal auditory canal has been documented in this paper the other three potential fistulous sites have not been described as yet The problem would be to define their anatomy in the congenitally malformed labyrinth they are different enough in their location to warrant an attempt to locate the exact fistulous site utilizing positive contrast techniques

At the time of surgery demonstration of a fistulous tract on the medial wall of the middle ear does not indicate or locate its intracranial origin Until proven otherwise the fundus of the internal auditory canal must be considered the most probable site of a bone dural discontinuity because of its anatomical relationships to the inner ear

When employing the techniques of positive contrast examination with Pantopaque one should be aware that if a cerebrospinal fluid leak is not present at the time of the examination the fistulous site will not be demonstrated Also if the site is very small the Pantopaque may not enter A very large hole will lead to quick passage of the Pantopaque and the fistulous site may be appreciated

A brief description of the anatomy of the internal auditory canal and posterior aspect of the petrous bone follows

Anatomy The internal auditory meatus is a prominent opening on the posterior surface of the petrous bone Fig 3 illustrates the gross appearance of the left canal after the dura has been stripped The transverse crest (falciform crest) is a bony ridge arising from the fundus of the canal and separates the canal into an upper and lower compartment the upper compartment being the smaller



Fig 3 Section of the right bony labyrinth at the level of the oval window (⟶) The fundus (⊸) is the thin bony wall convex medially separating the vestibule (⟷) from the internal auditory canal arising from the medial wall of the fundus is the transverse crest

(VALVASORRI & PIERCE 1964) The fundus of the internal auditory canal is an incomplete bony wall separating the canal from the inner ear As such, with its covering of arachnoid and dura mater, it is the barrier separating the inner ear from the subarachnoid space

In Fig 4 the bony canal has been widened, exposing the fundus and the numerous foramina for the nerves In infants, the foramina are more easily seen but it should be noted that the inner ear has attained its full size at birth (SCHAEFFER 1942) The foramen for the egress of the facial nerve and nervus intermedius into the middle ear is seen superiorly and anteriorly Immediately posterior are the foramina in the superior vestibular area for the fibers from the utricle and ampullae of the superior and lateral semicircular canals These nerve fibers combine to form the superior vestibular nerve Below the transverse crest are three sets of foramina Anteriorly and inferiorly the spiral cribriform tract locates the base of the cochlea with numerous foramina for branches of the auditory nerve In this projection, the foramen for the modiolus is not appreciated on this specimen Just posterior is the inferior vestibular area with numerous minute foramina for branches from the saccule which is immediately adjacent on the other side The most posterior and well defined opening is the foramen singulare through which the nerve from the ampulla of the posterior semicircular canal enters the fundus

The number of minute foramina supplying the membranous labyrinth exceeds 50 (BRASH & JAMIESON 1943) Another name for the fundus is lamina cribrosa, cribrous meaning sievelike

Three other potential sites of bone dural discontinuities on the posterior aspect of the petrous bone are also seen in Fig 4 The external opening of the cochlear aqueduct which transmits the perilymphatic duct and a small vein from the cochlea to the internal jugular vein is seen immediately above the jugular foramen Anatomically, the cochlear aqueduct furnishes a free communication be

tween the perilymph of the inner ear and the cerebrospinal fluid However, the channel is partially obliterated by fibrous tissue and is so narrow that it is not considered to provide a functional communication in the normal person (NEVZELIUS SKOLNIK & FERRER) Lateral to the internal auditory canal is a narrow fissure the aqueducts vestibuli in which lie the ductus endolymphaticus, an arteriole and venule as well as a process of connective tissue The endolymphatic duct ends in a blind terminal portion called the endolymphatic sac which lies under cover of the dura mater at the origin of the fissure (BRASH & JAMIESON) A bony passageway to the vestibule exists in the dried skull as evidenced by the ability to pass a bristle from the fissure to the vestibule (SCHAEFFER)

The fossa subarcuata in a normal adult is a blind pouch of varying size which transmits a small vein and a process of dura In fetal life it furnishes a pathway for blood vessels to enter and spongify the labyrinth thereby softening it to allow the semicircular canal to assume their adult position Thereafter the vessels atrophy However not infrequently a vessel passing under the arch of the superior semicircular canal persists and is known as the *subarcuate artery* (ANSON & DONALDSON 1967)

The frontal projection of a tomographic section shows the fundus (lamina cribrosa) as the common bony wall between the vestibule and the internal auditory canal (Fig 5) This frontal projection seems to be the simplest one to use for demonstrating the fundus and the vestibule (COMPERE & VALVASORRI 1964) In Stenvers projection the vestibule is directly below the simple limb of the superior semicircular canal When the rotation of the head *is greater than* 45 , the facial canal and the other foramina of the fundus may be seen and *should not* be mistaken for congenital defects (COMPERE & VALVASORRI)

Acknowledgement

Full recognition is given to our neurosurgical colleagues Frank E Nulsen the Harvey Huntington Brown Jr Professor of Neurosurgery at the *Case Western Reserve* University School of Medicine and Director of the Division of *Neurosurgery Department* of Surgery University Hospitals of Cleveland and to William F Collins Professor of Neurosurgery Yale Medical School for *their primary role in* the initiation of the pertinent diagnostic studies Dr Collins performed *both intracranial* neurosurgical procedures and Dr Lindsay L Pratt the original mastoidectomy

SUMMARY

The exact fistulous site in the fundus of the *internal auditory* canal was demonstrated by means of positive contrast medium in a *child with* recurrent meningitis and a congenitally malformed bony labyrinth The pertinent *anatomy of* the fundus of the internal auditory canal the cochlear aqueduct the *aqueductus vestibuli* and the foramen subarcuata are described

ZUSAMMENFASSUNG

Die exakte Lage von Fisteln im Fundus des inneren Gehörganges wurde mittels positiver Kontrastuntersuchung in einem Kind mit rezidivierender Meningitis und kongenitaler Missbildung des knöchernen Labyrinths festgestellt. Die Anatomie des Fundus des inneren Gehörganges, des Aquaeductus cochleae, des Canaliculus vestibuli und des Foramens der Fossa subarcuata wird beschrieben.

RÉSUMÉ

Les auteurs ont mis en évidence par un moyen de contraste positif le siège exact d'une fistule du fond du conduit auditif interne chez un enfant atteint de méningite récidivante et ayant une malformation congénitale du labyrinthe osseux. Ils décrivent l'anatomie du fond du conduit auditif interne, l'aqueduc cochléaire, l'aqueduc vestibulaire et le foramen de la fossa subarcuata.

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FROM THE NEURORADIOLOGY SECTION OF THE RADIOLOGY DEPARTMENT OF THE ALBERT EINSTEIN COLLEGE OF MEDICINE BRONX USA

'J' AND 'OMEGA' SHAPE OF SELLA TURCICA

Anatomic clarification of radiologic misconceptions

by

E LEON KIER

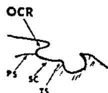
The use of the descriptive terms J sella or Omega sella is widespread in the literature and in the everyday clinical evaluation of infant skull roentgenograms Inspite of the frequent use of these terms by radiologists neurosurgeons neurologists and pediatricians there is considerable disagreement as to their diagnostic value

The extensive previous literature does not provide for an objective understanding of these terms The J and Omega sellae have been variously described as (1) specific features of certain pathologic conditions (2) abnormalities of a non specific nature (3) normal anatomic variations and (4) radiologic illusions

It is apparent that this unsatisfactory situation has resulted from the lack of basic correlative anatomic radiologic information about the changing features of the sphenoid bone during infancy

This information was provided by two anatomic radiologic studies of the developing sphenoid bone

In the first study (KIER 1966) the developmental anatomy of the normal optic canal and its anomalies were considered The material used consisted of 26 cleared and alizarin stained fetuses 120 dissected fetal infant and adult optic canals and 1 100 optic canals examined in dry fetal infant and adult skulls This



Misinterpreted normal sphenoids Sphenoids such as these are described in the literature as J and (or) Omega sellae All these cases demonstrate a distinct tuberculum sellae (TS) thus the term J sella would not apply to normal sphenoids such as these

Although an omega configuration is present in these cases the components of this configuration are a normal sulcus chiasmaticus (SC) and a prominent optic canal roof (OCR) The optic canal roof should not be mistaken for a planum sphenoidale Cases such as these have been misinterpreted as Omega sellae demonstrating an excavated sulcus chiasmaticus The inappropriate use of the terms J and Omega sellae in normal cases such as these has resulted in the loss of the diagnostic value of these terms



study defined the developmental anatomy of the optic canal and its radiologic manifestations The optic canal roof was found to increase progressively in size during fetal life and to remain a very prominent structure during early infancy In addition this study provided a developmental basis for the radiologic findings of (1) vertical optic canal asymmetry, (2) the absent floor of the cranial opening of the optic canal, and (3) the vertically large orbital opening of the canal in childhood These features should not be mistaken for pathologic changes

The second study (KIER 1968) concerned the developmental anatomy of the planum sphenoidale, sulcus chiasmaticus and tuberculum sellae The material used consisted of (A) 45 dissected fetal sphenoids, 18 dissected infant sphenoids, and 100 sphenoids examined in dry adult skulls, (B) lateral skull roentgenograms of 50 fetuses, 200 normal newborns, 100 normal infants and 85 infants with abnormalities All the infants had a partially developed sphenoid sinus This study correlated the developmental anatomy of the presellar sphenoid with its radiologic manifestations

With this information pathologic changes can be differentiated from normal growth patterns *An important feature is the postnatal development of the planum sphenoidale* This developmental pattern is of great importance in the radiologic evaluation of the sphenoid bone in lateral skull roentgenograms of young infants An elongated sulcus chiasmaticus prior to the formation of the planum sphenoidale should not be mistaken for an abnormal feature The normally prominent optic canal roof during early infancy should not be mistaken for the planum sphenoidale These mistakes account for many of the normal infants

presented in the literature as showing 'abnormal excavation of the sulcus chiasmaticus In effect, very few pathologic conditions present true abnormalities of the tuberculum sellae, sulcus chiasmaticus planum sphenoidale and the optic canal roof

Discussion

With the anatomic radiologic information gained from the developmental studies of the sphenoid bone it is now possible to re appraise the controversial J sella 'Omega sella and many other similar descriptive terms

The term J shaped sella was introduced by DAVIDOFF & EPSTEIN (1950) They stated roentgenograms of the skull showed an excavation of the tuberculum sellae, producing an exaggerated J shaped sella As originally defined the term J sella was intended to describe a particular sphenoid abnormality However over the years the term J sella has become diagnostically meaningless as a result of the incorrect application of this term to normal infantile *sphenoids* The incorrect use of this term is noted in the radiologic myth of the normal J sella

The developmental studies of the sphenoid indicate that an absent tuberculum sellae is a definite sign of abnormality Thus a sella cannot be both normal and J shaped In addition the term J sella has been incorrectly applied to many cases in which normal developmental patterns have been mistaken for pathologic changes (see the accompanying illustration)

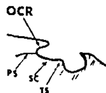
The Omega sella is defined (FOURNIER & DENIZET 1965) as a sella turcica in front of which the sulcus chiasmaticus is enlarged and abnormally deep A sella turcica associated with a truly excavated sulcus chiasmaticus does simulate the greek letter omega Any diagnostic specificity this term may have had has been lost by mistaking the normally prominent optic canal roof for an excavated chiasmaticus sulcus (see illustration)

Conclusions

The terms J and Omega sellae, as currently used are diagnostically meaningless and are harmful to the objective assessment of the sphenoid in infancy A normal J sella or a normal Omega sella are radiologic myths and should be discarded

SUMMARY

The anatomical background of the terms J sella and Omega sella is discussed and their diagnostic specificity is evaluated



Misinterpreted normal sphenoids Sphenoids such as these are described in the literature as J and (or) Omega sellae All these cases demonstrate a distinct tuberculum sellae (TS), thus the term J sella would not apply to normal sphenoids such as these

Although an omega configuration is present in these cases the components of this configuration are a normal sulcus chiasmaticus (SC) and a prominent optic canal roof (OCR) The optic canal roof should not be mistaken for a planum sphenoidale Cases such as these have been misinterpreted as Omega sellae demonstrating an excavated sulcus chiasmaticus *The inappropriate use of the terms J and Omega sellae in normal cases such as these has resulted in the loss of the diagnostic value of these terms*



study defined the developmental anatomy of the optic canal and its radiologic manifestations The optic canal roof was found to increase progressively in size during fetal life and to remain a very prominent structure during early infancy In addition this study provided a developmental basis for the radiologic findings of (1) vertical optic canal asymmetry, (2) the absent floor of the cranial opening of the optic canal, and (3) the vertically large orbital opening of the canal in childhood These features should not be mistaken for pathologic changes

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WIDENED VASCULAR GROOVES IN FIBROUS DYSPLASIA OF THE SKULL

by

M ROSENCRANTZ

Widening and tortuosity of the arterial grooves of the vault most commonly occur in meningioma and occasionally in angiomatous malformations A wide and tortuous groove running to a bone area of pathologic structure is even more suggestive of a meningioma Such a lesion may be present for a long time without causing clinical signs and the bone lesion may be an incidental finding It seems to be less well known that similar radiographic changes may also be seen in fibrous dysplasia Three cases of this kind are briefly reported, and the differential diagnosis is discussed

Case reports

Case 1 Female aged 51 with a painless mass in the left parietal region since she was 16 and no neurologic signs

Roentgen examination of the skull revealed a lesion of the left parietal bone (Fig 1)

Angiography of the left internal carotid artery was normal

External carotid angiography was also performed (Fig 2) Biopsy revealed fibrous dysplasia

Case 2 Female aged 20 with a slow growing tender mass in the right parietal region from early childhood and severe headache from the age of 8 No neurologic signs

Electroencephalography showed episodic abnormality with right sided predominance

ZUSAMMENFASSUNG

Die anatomischen Betrachtungen die zur Verwendung der Ausdrucke J Sella und , Omega Sella dienen werden analysiert und ihre diagnostische Spezifitat wird ausgewertet

RÉSUMÉ

L auteur etudie les bases anatomiques pour l application des termes sella en J et ella en omega et examine leur specificite diagnostique

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Fig 2 Case 1 Selective angiography of the left external carotid artery Enlargement of the middle meningeal artery and its posterior branch with ramifications to the bone lesion The lesion was obviously fed also by the unusually large parietal branch of the superficial temporal artery b) Subtraction method oblique lateral view There is a faint accumulation of contrast medium certain drainage veins can be seen

The lesion is microscopically characterized by replacement of bone by slowly expanding fairly well vascularized primitive connective tissue Varying amounts of metaplastic bone and occasionally cartilage are laid down in this abnormal tissue The skull is often affected in both the mono- and polyostotic form of the disease

The radiographic appearances vary considerably obviously depending upon the relative proportions of fibrous tissue and metaplastic bone in the lesion from a small well demarcated decalcified area in the diploe to a massive sclerotic overgrowth of bone Sclerotic lesions most frequently involve the facial bones and the base of the skull and cause a diffuse increase in the thickness of the bone More or less well demarcated mainly lytic lesions usually with varying degrees of sclerosis are most common in the calvarium especially in the frontal and parietal bones These produce widening of the diploic space and bulging of the outer table but the inner table is usually not involved A tangential view is necessary for the demonstration of these changes

Cranial involvement most frequently occurs in the base of the skull with the polyostotic form of fibrous dysplasia The typical distribution and characteristic appearances of the other skeletal lesions generally reveal the true nature of the condition If a cranial lesion is the sole manifestation of the disease however, diagnostic problems may arise It appears that the one lesion with which the condition may most easily be confused is meningioma This is particularly so in



Fig 1 Case 1 a) The widened groove of the posterior branch of the middle meningeal artery runs to a partly sclerotic and partly lytic lesion of the parietal bone b) Tangential view of the lesion *which is localized to the diploe and expands outwards thinning of the outer table the* inner table is intact

A large lesion of the right parietal bone was revealed on roentgen examination of the skull (Fig 3a) The lesion lay in the diploe and extended outwards partly at the expense of the thinned outer table and increased the thickness of the bone to about 3 cm The inner table was intact the right foramen spinosum was somewhat enlarged

Angiography of the right internal carotid artery was normal

Selective external carotid angiography was performed with the result demonstrated in Fig 3b The bone lesion was removed and microscopically proved to be in the nature of *fibrous dysplasia*

Case 3 Female aged 19 was admitted to hospital with head trauma after a car accident

Roentgen examination of the skull revealed a lesion of the right parietal bone (Fig 4)

On selective angiography of the right internal and external carotid arteries the findings were essentially the same as in the previous cases

The lesion was removed Microscopically it was found to represent fibrous dysplasia

Discussion

Fibrous dysplasia or Jaffe Lichtenstein s disease, is a fairly uncommon condition that may affect one or several of the bones It is a disorder of childhood and early adolescence, with no or only slight activity after puberty although the bone lesions usually persist throughout life The etiology is unknown

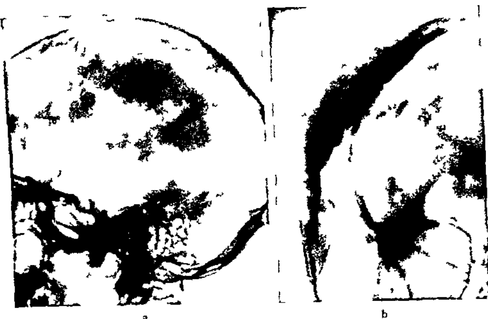


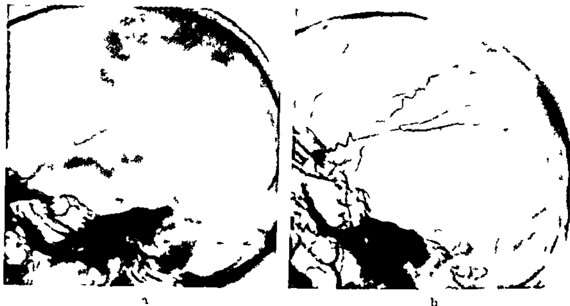
Fig 4 Case 3 a) Mainly lytic well demarcated lesion of the parietal bone Widening of the grooves of the middle meningeal artery and its posterior branches b) Tangential view of the lesion situated in the diploe and expanding outwards thinning of the outer table the inner table is partly eroded

cerning angiographic studies of fibrous dysplasia of the skull The increased vascularity can be established not only from the widened arterial grooves that lead to the lesion but may also be demonstrated by selective angiography of the external carotid artery

Fibrous dysplasia of the vault has thus generally been found to be more vascularized than normal bone The examiner should therefore not permit himself to be misled by the radiographic finding of a widened and tortuous arterial groove leading to a bone lesion The radiographic appearances of the bone lesion are fairly characteristic at least in tangential views and differ from those of most meningiomas Manifestations in other parts of the skeleton will support the diagnosis of fibrous dysplasia and should be sought if doubt exists

SUMMARY

Three cases of fibrous dysplasia of the vault are reported The radiographic appearances in this condition may be fairly similar to those encountered in cases of convexity meningioma Selective angiography of the external carotid artery was performed to demonstrate the vascularity of the lesion The differential diagnosis is discussed



a b

Fig 3 Case 2 a) Large and fairly well demarcated irregular and mainly lytic lesion of the parietal bone The grooves of the middle meningeal artery and its posterior branch are widened and somewhat tortuous Peripheral ramifications run into the lesion b) Selective angiography of the right external carotid artery Enlargement of the middle meningeal artery and its posterior branch and ramifications small straight vessels unlike tumour vessels are present in the lesion

the more circumscribed sclerotic lesions of the base of the skull Then, an accurate differentiation in conventional films between fibrous dysplasia and a meningioma of the en plaque type or an intraosseous meningioma may at times seem impossible When the structural changes of the bone involved are mainly lytic and they are localized to the calvarium, the appearances in meningioma and fibrous dysplasia may be fairly similar It is true though that fibrous dysplasia usually involves only the diploe and the outer table, whereas most meningiomas primarily involve the inner table Meningiomas may however occasionally grow mainly outwards, and in fibrous dysplasia the inner table may be partly destroyed, as illustrated by Case 3

Localized increase in vascularity has been reported as a characteristic feature of meningioma but thought to be absent in fibrous dysplasia (Feiring et coll 1951) In fibrous dysplasia of other bones a remarkable increase in the calibre of the regional vessels, arteries and veins both large and medium leading to a marked increase in the circulation rate has been reported (Mucchi & Columella 1951) Other statements to the contrary have been made (Maucelis & Murphy 1958) Isotope studies have disclosed a slight radioactivity uptake in skull lesions

The present author has not been able to find anything in the literature con

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RHINORRHEA AND HYDROCEPHALUS

Observations on spontaneous cerebrospinal fluid fistulae in patients with increased intracranial pressure

by

MANNIE M SCHECHTER RICHARD L ROVIT and JEROME M SCHACHTER

Cerebrospinal fluid rhinorrhea resulting from trauma is common and well documented Head injuries and cranial operations are responsible for most cases of rhinorrhea Other less common causes are infection of the paranasal sinuses with osteomyelitis of adjacent bone (32) congenital anomalies such as nasal meningoceles or meningoencephaloceles and destructive neoplastic lesions at the base of the skull

Since this may allow a better understanding of the etiology of the leakage of cerebrospinal fluid and the institution of appropriate diagnostic and therapeutic maneuvers we have elected to divide rhinorrhea into an obstructive and a non obstructive group In non-obstructive rhinorrhea by far the most common variety there is a gross, although not always demonstrable defect in bony and membranous coverings of the brain which allows the egress of cerebrospinal fluid into the nasal cavity The commonest cause of this is head trauma (Fig 1a)

The primary etiologic mechanism in this group is the disruption of bone and a rent in the overlying investing membranes of the brain Once this is corrected

ZUSAMMENFASSUNG

Es wird über drei Fälle fibröser Dysplasie des Schädeldaches berichtet. Die radiographischen Erscheinungen dieser Affektion können denen bei Konvexitätsmeningiom ziemlich ähnlich sein. Selektive Kontrastfüllung der A. carotis externa wurde vorgenommen, um die Gefässversorgung zu studieren. Die Differenzialdiagnose wird besprochen.

RÉSUMÉ

L'auteur présente trois cas de dysplasie fibreuse de la voûte du crâne donnant des images radiologiques semblables à celles des méningiomes de la convexité du cerveau. Il a fait des angiographies sélectives de l'artère carotide externe pour mettre en évidence la vascularisation de la lésion. Il étudie le diagnostic différentiel.

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Fig 2 Case 1 Ventriculogram p a projection Soft tissue mass in the third ventricle

Monro, and extirpation of these tumors eliminated the rhinorrhea The third patient presented with headaches and a watery discharge from the left nostril After removal of a large left parieto-occipital meningioma, the rhinorrhea slowed down considerably and ceased entirely after a subsequent duroplasty In the fourth patient with aqueductal stenosis cerebrospinal fluid rhinorrhea ceased only after a shunting procedure successfully reduced the increased intracranial pressure

Case reports

Case 1 A 41 year-old male presented to the emergency room of St Vincent s Hospital and Medical Center with a history of severe headaches and profuse rhinorrhea from the l ft nostril The rhinorrhea had appeared spontaneously 4 years previously Since that time it had been copious lasting 3 to 4 days during each attack During this 4 year period he had never been without the discharge for longer than a week A history of intermittent bifrontal headaches was elicited but no direct relationship between headaches and rhinorrhea could be established

Past history revealed that 13 years previously he had been admitted to another hospital several weeks after a trivial head injury complaining of headache lethargy blurred vision, and attacks of numbness and unsteadiness in both lower extremities Examination at that time revealed a dull affect papilloedema truncal ataxia and a positive left Babinski reflex

Skull roentgenograms were unremarkable Lumbar puncture revealed raised cerebrospinal fluid pres ure Encephalography disclosed poor filling of the ventricular system but with evidence of symmetri al ventricular dilatation Some of the air which entered the third ventricle appeared to b trapped in its posterior aspect Ventriculography was then performed and revealed gross ventricular dilatation secondary to an obstructing mass in the region of the foramen of Monro (Fig ?)

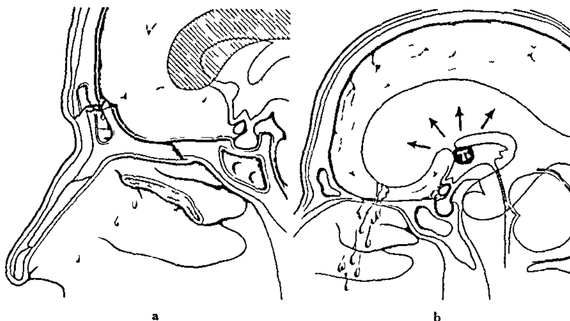


Fig 1 a) Non obstructive rhinorrhea resulting from trauma Fracture of the skull involving the frontal sinus and disruption of the investing membranes of the brain (The escape of cerebrospinal fluid is usually not as profuse as in the obstructive group) b) Obstructive rhinorrhea (Long standing or intermittent hydrocephalus is usually the etiologic factor)

either by the body s reparative processes or by direct surgical attack, the rhinorrhea should cease Obstructive rhinorrhea is far less common and has not received wide attention in the surgical or radiologic literature (Fig 1b) In this variety, it appears that the anatomical defect in the skull base is the direct consequence of long standing or intermittent severe hydrocephalus, the raised intracranial pressure gradually causes erosion usually of the cribriform plate and attenuation of the overlying investing membranes with eventual escape of cerebrospinal fluid into the nose Cerebrospinal fluid rhinorrhea may occur spontaneously, although in some instances it appears that a trivial head injury may serve as the terminal insult which is responsible for complete disruption of an already thinned out cribriform plate In instances of obstructive rhinorrhea while efforts may be directed to primary closure of the anatomical defect, resolution of the rhinorrhea represents only one and perhaps the least significant aspect of the basic problem In fact, closure of the fistulous tract may even be counter productive Proper therapy in these cases must be directed towards defining the source of increased intracranial pressure and eliminating it

In this report we wish to present four patients with rhinorrhea caused by obstructing intracranial lesions Two of these patients had benign circumscribed mass lesions obstructing the cerebrospinal fluid pathways at the foramen of



Fig 4 Case 1 Ventricular size before (a) and after (b) removal of the colloid cyst

was performed and through the dilated right lateral ventricle the colloid cyst was delivered and excised

The patient's postoperative course was uneventful At repeat encephalography one month after operation the mass was no longer present and air passed freely into both lateral ventricles from below (Fig 3b) The lateral ventricles were less dilated than at the previous examination and the ventriculo-nasal fistulous tract could no longer be identified (Figs 3b and 4b) There has been no cerebrospinal fluid rhinorrhea since the operation

Case 2 A 48-year old male was seen in neurosurgical consultation with a history of clear colorless rhinorrhea which first had appeared one year previously The rhinorrhea occurred daily usually in the morning on shaving and the patient believed that he could collect more than one ounce of fluid at any given time The rhinorrhea ceased spontaneously after 3 months and there was no headaches There was a history of progressive visual loss in the right eye for about one year and in the left eye for one week

A lumbar puncture and bilateral carotid angiography had been performed previously and were considered normal Positive findings on neurologic examination were decreased visual activity with optic atrophy on the right side and papilloedema in the left eye There was a left inferior quadrantanopsia Otherwise the examination was within normal limits

The patient was admitted to hospital and encephalography was performed The lateral ventricles were moderately dilated and a mass was seen in the third ventricle in the region of the foramen of Monro (Fig 5a) At operation this proved to be a papilloma of the choroid plexus of the third ventricle extending into the right foramen of Monro and this was removed through the right lateral ventricle without incident His postoperative course was uneventful There was slight improvement in vision and resolution of the papilloedema. Repeat encephalography performed 2 years after the operation revealed persistent ventricular dilatation but no evidence of intra or extraventricular obstruction (Fig 5b) This patient



a



b

Fig 3 Case 1 a) Encephalography 13 years later than in fig 2 Distended lateral ventricles and fistulous tract outlined by air extending to ethmoid sinuses A rounded mass with the typical appearance of a colloid cyst is encroaching upon the foramen of Monro b) Encephalography performed one month after removal of the cyst A wide patent foramen of Monro the colloid cyst is no longer seen

The patient received radiation therapy with the presumptive diagnosis of a glioma of the third ventricle Headaches papilloedema and ataxia were no longer present following radiation therapy Despite multiple interviews with the patient and his family we were unable to obtain a precise account of his symptoms in the years between hospitalizations Suffice it to say that he worked steadily in a semi skilled job during this entire period and was essentially symptom free until his rhinorrhea developed 9 years later

On present admission to hospital no physical or neurologic abnormalities other than the profuse left rhinorrhea could be demonstrated Specifically no papilloedema was present Cerebrospinal fluid pressure 2 days after admission was normal

Conventional skull films and bifrontal cranial tomograms were unremarkable RISA cisternography was undertaken in an attempt to localize the fistulous tract but unfortunately no rhinorrhea was present during the test period It seemed reasonable to assume that the rhinorrhea was in some way related to the mass previously demonstrated in the third ventricle and we therefore thought it appropriate to redefine this region to better advantage Encephalography revealed a round mass in the third ventricle posterior to and encroaching upon the foramen of Monro Air passed beyond this mass into the lateral ventricles which were dilated but not to the degree seen 13 years previously The mass had the typical radiographic appearance of a colloid cyst of the third ventricle A fistulous tract outlined with air appeared to extend from the inferior aspect of the frontal horn of one lateral ventricle towards the ipsilateral ethmoidal sinus (Fig 3a)

The rhinorrhea and the fistulous tract appeared to be the consequence of intermittent partial obstruction at the foramen of Monro and therefore our initial maneuver was directed towards removing the mass in the third ventricle If this were successful it was felt that the cerebrospinal fluid fistula might close spontaneously Accordingly a right frontal craniotomy

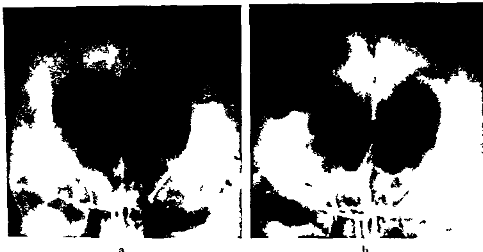


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Fig 5 Case 2 a) Encephalography Mass in the third ventricle obstructing the cerebrospinal fluid pathways (The mass a choroid plexus papilloma was removed at surgery) b) Encephalography performed 2 years later shows a large patent foramen of Monro

has been followed for 4 years since the operation without recurrence of cerebrospinal fluid rhinorrhea

Case 3 A 21 year old farm worker was admitted to hospital with a 3 week history of headaches and a watery discharge from the left nostril Neurologic examination revealed mild euphoria and slight slurring of speech There was bilateral papilloedema The right pupil was slightly larger than the left but both quickly reacted to light and accomodation Extra ocular movements were full and equal There was no nystagmus There was a mild right facial hypesthesia and a diminished right corneal reflex Deep tendon reflexes were increased on the right side

Skull roentgenograms revealed a large calcification in the left parieto occipital area Bi lateral carotid angiography disclosed a tumor mass having some increased vascularity in this region

Left parieto occipital craniotomy revealed a large cystic mass containing about 150 ml milky fluid with crystalline material The tumor which also contained calcium was totally removed Pathologic sections disclosed a meningioma After operation the cerebrospinal fluid rhinorrhea slowed down considerably but did not stop entirely

About 4 weeks after operation ventriculography revealed a gas filled tract running from the anterior horn of the left lateral ventricle to the region of the cribriform plate Therefore about 2 months later the floor of the left frontal fossa was explored through a left frontal craniotomy exposure The fistulous tract was identified and a small protrusion of cortex was found attached to a dehiscence in the dura in the region of the left cribriform plate The

cortex was freed and the dural rent was repaired Following this operation cerebrospinal fluid rhinorrhea ceased entirely and has not returned since The latest follow up visit was 1? years later

The patient had an episode of meningitis which was treated at another hospital about a year after his last visit to our hospital No information on the offending organi ms has been available

Case 4 A 39 year-old female was admitted to hospital with a complaint of discharge of clear fluid from her nose She had a history of headaches associated with nausea and vomit ing dating back 10 years The e persi ted until 4 months before admission when suddenly he developed the onset of drainage of clear fluid from her right nostril at which time the headaches dramatically ceased Neurologic examination was unremarkable apart from anos mia on the right side

Skull roentgenograms showed an enlarged sella turcica with severely demineralized poste rior clinoids Encephalography revealed tonsillar herniation and was discontinued in favor of ventriculography This demonstrated ventricular dilatation secondary to a benign stenosis of the aqueduct of Sylvius Immediately following the ventriculographic examination the patient underwent a lateral ventriculocisternostomy (Torkildsen shunt) Following this proce dure and a sub equent hortening of the ventricular tubing the patient had a cessation of her rhinorrhea

About 2 months later the patient was readmitted to the hospital with recurrence of cere brospinal fluid rhinorrhea and headaches Lumbar puncture revealed elevated cerebrospinal fluid pressure The shunt was revised 3 days later and postoperatively the patient again noted cessation of her rhinorrhea This respite was short lived lasting only 3 days when she again had a small amount of drainage from the right nostril The patient elected to leave the hospital and to return at a later date for re evaluation

She was readmitted after 5 weeks with persistent rhinorrhea and recurrent headaches Apart from blurring of the disk margins no neurologi abnormality was found Two days later through a right frontal craniotomy a defect in the cribriform plate which contained protruding brain was exposed The herniated cerebral tissue was excised and the bone defect was repaired with muscle and surgical

One week after operation the patient developed increasingly severe headaches and nausea and 3 days later a ventricular puncture revealed a pressure of 300 mm of water Indigo carmine dye injected into the ventricle did not pass to the lumbar subarachnoid space The patient had a ventriculo-atrial shunt (Pudenz) about 10 days later and thereafter she seemed to feel much improved Lumbar puncture a further 3 days later still showed increased cerebrospinal fluid pressure (?80 mm H O) and a small plug of choroid plexus was removed from the ventricular catheter Postoperatively headaches and nausea were improved

The patient then did relatively well for about half a year when an intermittent spiking fever was noticed Four months thereafter she was admitted to hospital in a semi comatose stat Cerebrospinal fluid examination at this time revealed evidence of meningitis but no pecific organism could be identified Massive doses of antibiotics were administered and after a stormy course she gradually became progressively more alert Ventricular punc ture revealed no further evidence of meningitis and radioisotopic ventriculography was per f rm d the isotop did not leave the ventri le Although she had recovered from the me nin iti by now it was apparent that she still had increased intracranial pressure The Tor kild en shunt was revi ed a few days later and the entire Pudenz shunt was removed A new Pud nz shunt with a Coe type reservoir was in erted An attempt wa made to pass th s

down the jugular vein but a thrombosed superior vena cava prevented this and the distal end was placed in the peritoneal cavity. This functioned poorly and 17 days later right thoracotomy was performed and the tip of the shunt was inserted directly into the right atrium. Postoperatively, the patient did very well, having a short febrile course in the early postoperative period which cleared.

The patient was discharged from the hospital after a further 2 weeks, markedly improved and free from rhinorrhea, headaches, nausea and fever.

Discussion

Spontaneous cerebrospinal fluid rhinorrhea according to O'CONNELL (28, 29) simply indicates that the discharge is not an immediate or delayed result of trauma. Cases of spontaneous cerebrospinal fluid rhinorrhea were divided by O'CONNELL into two distinct groups, secondary and primary. In the secondary group, an obvious cause for the leak was present, e.g. tumor erosion or an old fracture site at the cranial base. In the primary group, no cause for the cerebrospinal fluid leak was immediately obvious. We would emphasize that all rhinorrhea is secondary, the consequence of some abnormality which allows the escape of cerebrospinal fluid through normally inviolate membranes and bony barriers.

O'CONNELL has claimed that the first description of spontaneous cerebrospinal fluid rhinorrhea was given by MILLER in 1826 (23). A boy with a progressively enlarging head developed a recurring discharge of fluid from the nose. At necropsy a large internal hydrocephalus was revealed and the fistulous tract between the cranial cavity and the nose was demonstrated.

Subsequent case reports have followed, and the entire subject of non-traumatic cerebrospinal fluid rhinorrhea has been adequately dealt with by other workers (19, 22, 20, 29, 12). Various contributing factors have been considered in the etiology of 'spontaneous' cerebrospinal fluid rhinorrhea. O'CONNELL (29) thought that the normal rhythmic variations in the pressure of the cerebrospinal fluid, which he had observed previously in 1953 (28), could pave the way for a leak *if an anatomical defect made the cribriform plate more vulnerable* to the full effects of this tidal movement. Such cribriform plate thinning might develop only after a prolonged exposure to raised pressure and would be compatible with the lag between the initial evidence of increased intracranial pressure and the later appearance of the rhinorrhea. JAUREGG (15) claimed that any act which increases intracranial pressure suddenly, such as sneezing, could force open a pathway which hitherto was not apparent.

Suggestions for potential pathways that might serve as the route of transmission of the cerebrospinal fluid from the intracranial cavity into the nose have included a remnant of the craniopharyngeal canal (19, 17), a fistula in a retained embryonic lumen of the olfactory bulb (7), or holes in the cribriform plate not completely occupied by fibers of the olfactory nerve (6). RAND (30) sug

gested that meningeal dysplasia in the region of the olfactory nerves was the most probable anatomical defect in cases of spontaneous rhinorrhea. This was re-emphasized by NUSSEY (27) The etiology of these meningeal defects are not apparent, but they have been described in association with bone defects in the region of the cribriform plate and are presumably related to constitutional or developmental factors (1 2)

With such potential albeit dormant pathways existing between the intracranial and nasal cavities it is not surprising that cerebrospinal fluid may be expelled into the nose when the intracranial pressure is increased This situation may be compounded further under conditions where long standing raised intracranial pressure causes thinning of the floor of the anterior cranial fossa (14) Under these circumstances, disruption of the cribriform plates with the production of a direct fistulous tract into the nasal sinuses may take place either spontaneously or following what would otherwise have been a trivial traumatic insult

The association of intracranial tumors with spontaneous cerebrospinal fluid rhinorrhea is not common but has been described with a variety of neoplasms occurring at the base of the cranial cavity Pituitary adenomas which produce erosion of the floor of the sella turcica are the commonest neoplasms associated with spontaneous cerebrospinal fluid rhinorrhea (25), but other tumors such as meningiomas craniopharyngiomas osteomas and nasopharyngeal tumors have also been incriminated (31 32 1, 3 5 22 9) The rhinorrhea which ensues under these circumstances is the direct consequence of destruction by neoplasm of the bony and membranous barriers separating the cerebrospinal fluid containing pathways and the nasal cavity The resultant cerebrospinal fluid leakage is thus not unlike that resulting from any insult for example trauma which produces disruption at the cranial base

The cerebrospinal fluid rhinorrhea in the four cases which we have presented has a different etiology The fistulae which developed in each of the four cases resulted from prolonged elevations of intracranial pressure rather than a destructive process at the cranial base We have proposed the term *high pressure cerebrospinal fluid rhinorrhea* to emphasize the probable underlying pathophysiology in these patients whose rhinorrhea appears to result primarily from obstruction of the cerebrospinal fluid pathways

A brief summary of the mechanism of cerebrospinal fluid obstruction and rhinorrhea and their amelioration following surgery in our four cases is appropriate at this juncture The cerebrospinal fluid rhinorrhea ceased following the removal of a colloid cyst of the third ventricle in Case 1 and repeat encephalography a month after operation showed partial resolution of the hydrocephalus and obliteration of the fistulous tract In Case 2 cerebrospinal fluid rhinorrhea had ceased spontaneously several months before definitive diagnostic studies were

obtained. These revealed an obstructive hydrocephalus secondary to what was proven to be a papilloma of the choroid plexus of the third ventricle. Successful removal of this mass was accomplished and rhinorrhea has not reappeared. In Case 3, although rhinorrhea abated following removal of a large parieto-occipital meningioma, it did not entirely cease. Ventriculography performed a month after surgery still revealed some obstruction to the ventricular system and a fistulous tract between the anterior horn of the lateral ventricle and the cribriform plate could be demonstrated. A subsequent intracranial repair of the dura was necessary for complete obliteration of the rhinorrhea. In Case 4, having aqueductal stenosis, rhinorrhea continued to be present despite an attempt to seal off the fistulous tract intracranially. The cerebrospinal fluid leak ceased only after a successful ventriculo-atrial shunt had reduced the raised intraventricular pressure above the constricted aqueduct.

In neither Case 1 nor in Case 2 was surgery directed towards obliteration of the fistulous tract. In fact, to have done so might have been disastrous since this would have eliminated an apparent 'safety valve' with possible precipitation of an acute increase of intracranial pressure.

It is apparent that the fistulous tract may not be completely obliterated following removal of the primary obstructing lesion. This is apparent from the sequence of events in Case 3. Although previously profuse rhinorrhea abated after removal of the parieto-occipital meningioma it did not cease entirely and a persistent ventriculo-nasal fistula could still be demonstrated one month after surgery. It is possible that with a more prolonged period of observation and further reduction of the increased pressure induced by operation, the fistulous tract would have collapsed completely, but this is purely conjectural.

Case 4 illustrates the pathophysiology of these patients with high pressure cerebrospinal fluid rhinorrhea in a most vivid fashion. This patient with an aqueductal stenosis, and profuse rhinorrhea, had numerous shunting procedures in addition to an intracranial attack on the fistulous tract. When the shunts adequately bypassed the stenosed aqueduct, there was dramatic cessation of the rhinorrhea and conversely profuse cerebrospinal fluid discharge reappeared almost immediately with mechanical failure of the shunt. Only after the distal end of the shunt had been implanted directly into the right heart was there permanent cessation of the rhinorrhea.

Instances of spontaneous high pressure cerebrospinal fluid rhinorrhea comparable to those in the patients we have just described are most unusual. A search of the literature revealed an additional 15 cases making a total of 19 well documented cases of spontaneous high pressure cerebrospinal fluid rhinorrhea. Several interesting facts emerged from a study of these cases. The location of the cerebrospinal fluid block appears to be a prime determining factor in this type of cerebro

Table 1

Location of obstructing lesions

I Supratentorial

A *Hemisphere*
1—Frontal tuberculoma (MUKHERJI)
2—Parieto-occipital meningioma (our Case 3)

B *Suprasellar*
1—Pituitary (SOM & KRAMER)

C *Pineal region*
1—Tumor quadrigeminal body (NOTHNAGEL)
2—pineal tumor (LOCKE's Case 3)

D *Foramen of Monro*
1—Colloid cyst 3rd ventricle (our Case 1)
2—*Choroid plexus papilloma 3rd ventricle* (our Case 2)

II Infratentorial

A *Aqueduct*
1—Aqueduct stenosis (our Case 4)

B *Intraventricular mass 4th ventricle*
1—Medulloblastoma (BRITT)
2—Choroid plexus papilloma (VIGOUROUX)
3—Epithelial cyst (LOVE & WHITE)

C *4th ventricle obstruction extraaxial mass*
1—Cerebral astrocytoma (CAIRNS)
2—Basilar arachnoiditis (SHEA)
3—Cerebellar meningioma (CONFORTI et coll.)
4—Arnold Chiari malformation (YOUNGS & PEYTON)

D *Cerebello-pontine angle tumor*
1—CPA tumor and tumor (R) frontal lobe (LOCKE's Case 1)
2—Acoustic neurinoma (CUSHING)
3—CPA tumor (SOLQUES & ODIER)
4—CPA tumors bilateral (BARRETT)

Table 2

Chronological relationship of rhinorrhea and symptoms of increased intracranial pressure

I Rhinorrhea preceded ICP
1—YOUNGS & PEYTON (about 5 months)
2—Our Case 2 (about 1 year)
3—LOVE & WHITE (about 3 years)

II ICP preceded rhinorrhea
1—CUSHING (short time)
2—MUKHERJI (six months)
3—CONFORTI et coll. (1 year)
4—SOM & KRAMER (3 years)
5—SHEA (several years)
6—NOTHNAGEL (4 years)
7—LOCKE's Case 1 (7 years)
8—Our Case 1 (9 years)
9—Our Case 4 (10 years)
10—BRITT (12 years)
11—CAIRNS (14 years)

III ICP and rhinorrhea same duration
1—Our Case 3 (about 3 weeks)

IV Not clearly defined
1—LOCKE's Case 3
2—VIGOUROUX
3—SOLQUES & ODIER
4—BARRETT

spinal fluid rhinorrhea

It may be seen from Table 1 that the obstruction of the cerebrospinal fluid pathways was almost always confined to the ventricular system with the majority of lesions situated in or around the 4th ventricle and aqueduct. There were only two instances of supratentorial hemispheral lesions, both of which produced a high degree of ventricular obstruction. In three instances the obstruction primarily involved the foramen of Monro. In the other two instances which fall into the

Table 3

Location of fistulous tract

I Ventriculo nasal
- 1—Britt (fistula to right lateral ventricle and temporal horns)
- 2—Souques & Odier
- 3—Cushing
- 4—Our Case 1
- 5—Our Case 3
- 6—Mukherji (probably)

II Subarachnoid space—nasal cavity
- 1—Nothnagel (probably)
- 2—Locke's Case 1
- 3—Vigouroux
- 4—Shea
- 5—Love & White
- 6—Som & Kramer
- 7—Our Case 4

III No definite information
- 1—Locke's Case 3
- 2—Cairns
- 3—Conforti et coll
- 4—Youngs & Peyton
- 5—Our Case 2
- 6—Barrett

Table 4

Effects of operative procedures in rhinorrhea

I Rhinorrhea ceased after obstruction was relieved

A *Without duroplasty*
- 1—Conforti et coll
- 2—Our Case 1

B *With duroplasty*
- 1—Mukherji
- 2—Our Case 4

II Rhinorrhea did not stop after obstruction

A *Without duroplasty*
- 1—Cushing (patient died of subsequent meningitis)
- 2—Cairns
- 3—Youngs & Peyton

B *With duroplasty*
- 1—Love & White (finally stopped 2 years after relief of obstruction)
- 2—Our Case 3

III Rhinorrhea stopped spontaneously before relief of obstruction
- 1—Our Case 2

supratentorial ventricular obstruction group, the pathology was located in the region of the posterior 3rd ventricle and undoubtedly involved the proximal aqueduct as well. In twelve of the nineteen cases, the obstructing lesion was located below the tentorium. These included one instance of a pure aqueductal stenosis, three intraventricular neoplasms (4th ventricle), and eight cases where the 4th ventricle obstruction arose on the basis of intra- or extra-axial lesions blocking the exit foramina of the 4th ventricle.

Not only is the location of the obstructing lesion important but the relatively static nature or extremely slow rate of growth of the lesion must be a dominant factor. Two cases had lesions starting at early life (aqueductal stenosis, Arnold Chiari malformation). One case had an arachnoiditis surrounding the exit foramina of the 4th ventricle. Of the 13 cases where the ventricular obstruction was associated with histologically proven neoplasms, in only one instance was the offending tumor a malignant one (medulloblastoma), and even in this case, an un-

usually long history, 12 years was elicited between the initial symptoms of increased intracranial pressure and the subsequent onset of rhinorrhea. In summary it appears that cases of spontaneous high pressure cerebrospinal fluid rhinorrhea usually develop on a background of obstruction of the ventricular system usually in the posterior fossa related to slowly growing or static lesions

The relationship of the rhinorrhea to signs or symptoms of increased intracranial pressure in these nineteen cases is outlined in Table 2 Evidence of increased intracranial pressure preceded the onset of rhinorrhea in eleven cases with the time interval ranging from 6 months to 14 years In three previously asymptomatic patients spontaneous cerebrospinal fluid rhinorrhea brought them to the attention of the physicians Despite the paucity of symptoms in these three patients, an examination revealed unmistakable evidence of relatively long standing raised intracranial pressure In one instance (Case 3) rhinorrhea and symptoms of increased intracranial pressure developed simultaneously

In four patients the clinical protocols did not allow clear delineation of the chronology of the events In three patients who already had clear evidence of increased intracranial pressure a traumatic incident seemed to be related to the onset of rhinorrhea In one patient it is questionable whether trauma was a factor in the production of rhinorrhea

Information concerning the location of the fistulous tract was available in thirteen of the nineteen cases (Table 3) Clear evidence of a fistulous tract connecting the ventricular system with the paranasal sinuses was elicited in six instances The fistula usually arose from a frontal horn of one lateral ventricle In one case (7) multiple fistulae linked the paranasal sinuses with the frontal horn and both temporal horns. In seven cases there was operative or post mortem evidence of perforations in the dura overlying the cribriform plate without definite evidence of a further direct communication with the ventricular system It has been suggested that primarily long standing ventricular obstruction can induce secondary dilation and obstruction of the subarachnoid spaces (13 16) Accordingly a subarachnoid space nasal fistula might serve as a decompression vent for these cases even if the primary site of obstruction was in the ventricular system in a manner similar to the decompression effects afforded by a bone removal in subtemporal or suboccipital regions While the above mechanism may be operative it is also possible that instances of transcerebral fistulae connecting the lateral ventricle with the subarachnoid space were present but not appreciated in some of the cases in the category of simple perforations of the olfactory dura. In six instances no clear information relative to the internal opening of the cerebrospinal fluid fistulae was available

In the majority of instances especially in the early literature attempts were made to seal off the cerebrospinal fluid leakage by direct intranasal or intra

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- 1—Locke's Case 3
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usually long history, 12 years was elicited between the initial symptoms of in creased intracranial pressure and the subsequent onset of rhinorrhea. In sum mary, it appears that cases of spontaneous high pressure cerebrospinal fluid rhinorrhea usually develop on a background of obstruction of the ventricular system usually in the posterior fossa related to slowly growing or static lesions

The relationship of the rhinorrhea to signs or symptoms of increased intra cranial pressure in these nineteen cases is outlined in Table 2 Evidence of in creased intracranial pressure preceded the onset of rhinorrhea in eleven cases with the time interval ranging from 6 months to 14 years In three previously asymptomatic patients spontaneous cerebrospinal fluid rhinorrhea brought them to the attention of the physicians Despite the paucity of symptoms in these three patients an examination revealed unmistakable evidence of relatively long stand ing raised intracranial pressure In one instance (Case 3), rhinorrhea and symp toms of increased intracranial pressure developed simultaneously

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In the majority of instances especially in the early literature attempts were made to seal off the cerebrospinal fluid leakage by direct intranasal or intra

cranial procedures, before dealing with the problem of the ventricular obstruction This is well nigh impossible and we are not aware of any case where permanent cessation of cerebrospinal fluid leakage was obtained by this maneuver (Table 4)

An appreciation of the pathogenesis of the cerebrospinal fluid fistulae is therefore of prime importance The obstructing lesion must be dealt with initially In two instances, CONFORTI et coll (10) and our Case 1, cerebrospinal fluid leakage ceased entirely after the obstructing lesion was removed In three other instances, the cerebrospinal fluid leak was reduced to an occasional trickle after reconstruction of the cerebrospinal fluid pathways In several cases, secondary intracranial duroplastics were performed after relief of ventricular obstruction to provide permanent complete relief of rhinorrhea It may be that a secondary operation to seal off the dural opening is the procedure of choice, even in instances where rhinorrhea has ceased after elimination of the obstruction An atretic non functioning tract may still serve as a potential pathway for the subsequent introduction of infection into the intracranial cavity Meningitis is not an uncommon event in these patients with high pressure cerebrospinal fluid rhinorrhea In this series of nineteen cases of high pressure cerebrospinal fluid rhinorrhea, thirteen cases had one or more proven attacks of meningitis and seven of these succumbed to the overwhelming intracranial sepsis

Acknowledgement

We are grateful to Dr Hans Thomas Newton who supplied us with Cases 3 and 4

SUMMARY

Four cases of rhinorrhea associated with lesions obstructing the cerebrospinal fluid pathways are reported Two had benign circumscribed lesions obstructing the foramen of Monro the third had a parieto occipital meningioma and the fourth aqueductal stenosis In all cases surgery was directed to the obstructive lesion with cessation or relief of the rhinorrhea The term high pressure cerebrospinal fluid rhinorrhea is proposed to emphasize the probable pathophysiologic origin of the rhinorrhea in these cases as it appears to result primarily from obstruction of the cerebrospinal fluid pathways With an additional 15 cases from the literature this makes a total of 19 cases of well documented spontaneous high pressure cerebrospinal fluid rhinorrhea These cases are analyzed and discussed

ZUSAMMENFASSUNG

Vier Falle von Rhinorrhoe verbunden mit einengenden Prozessen der cerebro spinalen Flussigkeitswege werden beschrieben Zwei Falle hatten benigne umschriebene Lasionen die dass Foramen Monroi einengten der dritte hatte ein parieto occipitales Meningiom der vierte eine Stenose des Aquaeductus In allen Fallen richtete sich eine operative Behandlung gegen die obstruktiven Veranderungen und hatte eine verminderte oder aufgehobene Rhinorrhoe zur Folge Der Ausdruck Cerebro spinale Flussigkeitshochdruck

Rhinorrhoe durfte den wahrscheinlichen pathophysiologischen Hintergrund der Rhinorrhoe in diesen Fallen hervorheben, da diese primar durch Obstruktion der cer bro-spinalen Flussigkeitswege verursacht zu werden scheint Zusammen mit weiteren 15 Fallen aus der Literatur liegen zu ammen 19 wohl dokumentierte Falle einer spontanen cerebro spinalen Flu si keitshochdru k Rhinorrhoe vor Diese Falle werden analy iert und besprrchen

RÉSUMÉ

Les auteurs presentent quatre cas d rhinorrhee en rapport avec des lésions obstruant les voies du liquid céphalo rachidien Deux de ces malades avaient des lesions benignes circon crites obstruant le trou de Monro le troisième avait un ménin iome pariéto-occipital et le quatrieme une sténose de l aqueduc Dans tous ces cas l intervention chirurgicale a porté sur la lesion ob tructive et a fait ce er ou diminuer la rhinorrhée Les auteurs propo ent le terme de rhinorrhée par hypertension du liquide cephalo-rachidien afin de souligner l origine physio-pathologique probable de la rhinorrhée chez ces malades étant donné qu elle parait résulter de l obstruction des voies d écoulement du liquide cephalo-rachidien Avec 15 autres cas de la litterature ceci fait un total de 19 cas bien examinés de rhinorrhee spontanee par hypertension du liquide cephalo-rachidien Ces cas sont analysés et discutes

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FRANCE

RADIO ANATOMIE DE LA COCHLEE

Recherche d incidences tomographiques et limites de visibilite

par

J VIGNAUD M JUSTER H LERICHE, R LICHTENBERG et G KORACH

La mise en evidence de la cochlee par la tomographie necessite la recherche d incidences qui placent electivement les parois a etudier perpendiculairement au plan de coupe afin de respecter les lois de formation de l image tomographique

Cette condition est importante comme le montre l experience suivante

Un tube de verre a ete tomographie en balayage hypocycloidal perpendiculairement a son grand axe puis a ete progressivement incline par rapport au plan de coupe

A partir de 30 les regions non contenues dans un plan perpendiculaire au film disparaissent totalement (Fig 1)

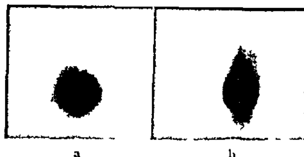
Mise a part l origine du tour basal la cochlee est, en fait un tube regulierement enroule en spirale autour d un cone la columelle

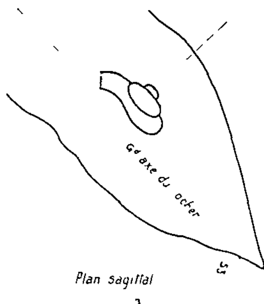
Les coupes contenant l axe de la columelle abordent normalement toutes les parois sectionnees

Les coupes perpendiculaires a l axe de la pyramide et passant par le plan equatorial de chaque etage sont aussi normales aux parois interessees

La situation de l axe de la columelle par rapport aux plans de reference apparait donc d un interet capital pour la determination des incidences

Fig. 1. Section d'un tube de verre en balayage hypocycloïdal. a) Tube perpendiculaire au plan de coupe. b) Tube incliné de 30° par rapport à la position initiale.





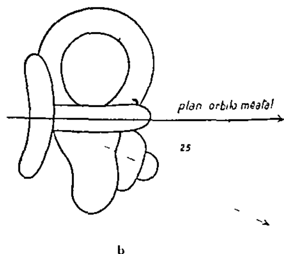


Fig. 2. Axe de la columelle par rapport au grand axe du rocher (a) et par rapport au plan orbito méatal (b) (vue postérieure).

Cet axe est situé dans un plan perpendiculaire au grand axe du rocher (Fig. 2). Par rapport au plan orbito-méatal, des mesures effectuées sur les tomographies pratiquées en incidence de Poschl (incidence axiale de la pyramide), en mesurant directement l'angle formé par l'axe de la columelle et le canal semi-circulaire externe, montre qu'il est incliné vers le bas de 20 à 30° (Fig. 3).

Incidences parallèles à l'axe de la columelle. L'incidence axiale de la pyramide décrite par Poschl consiste à placer le grand axe du rocher perpendiculaire au film.

Trois coupes sont intéressantes : l'une contenant l'axe de la columelle montre une section anatomique de la cochlée avec les trois étages superposés la columelle

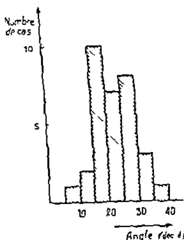


Fig 3 Répartition de la valeur de l'angle formé par l'axe de la columelle et plan orbito-méatal chez 32 adultes







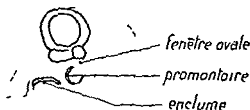



Fig 4 Tomographie en incidence de Poschl (axiale de la pyramide) Comparaison avec des microradiographies de tranches correspondantes C A I = Conduit auditif interne *En haut* Coupe contenant l'axe de la columelle *Au milieu* Coupe passant par le tour basal *En bas* Coupe passant par la fenêtre ovale et le promontoire

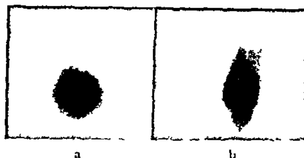


Fig. 1. Section d'un tube de verre en balayage hypocycloïdal. a) Tube perpendiculaire au plan de coupe. b) Tube incliné de 30° par rapport à la position initiale.

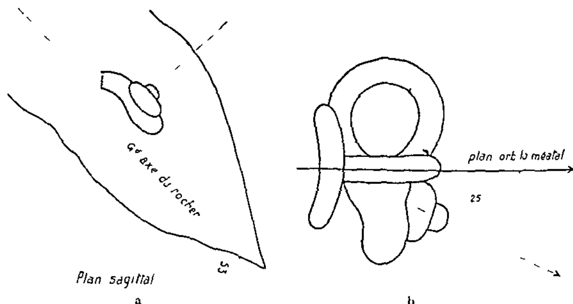


Fig. 2. Axe de la columelle par rapport au grand axe du rocher (a) et par rapport au plan *orbito-méatal (b) (vue postérieure).*

Cet axe est situé dans un plan perpendiculaire au grand axe du rocher (Fig. 2). Par rapport au plan orbito-méatal, des mesures effectuées sur les tomographies pratiquées en incidence de Pöschl (incidence axiale de la pyramide), en mesurant directement l'angle formé par l'axe de la columelle et le canal semi-circulaire externe, montre qu'il est incliné vers le bas de 20 à 30° (Fig. 3).

Incidences parallèles à l'axe de la columelle. L'incidence axiale de la pyramide décrite par Pöschl consiste à placer le grand axe du rocher perpendiculaire au film.

Trois coupes sont intéressantes : l'une contenant l'axe de la columelle montre une section anatomique de la cochlée avec les trois étages superposés, la columelle

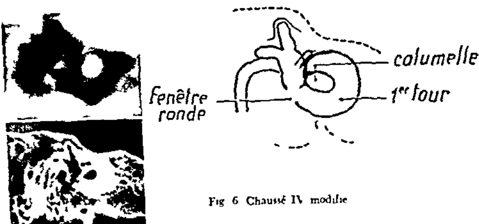


Fig 6 Chaussé IV modifié

Incidences perpendiculaires à l axe de la columelle C est l incidence de Chaussé IV modifié en surrelevant le coté radiographié de 20 à 30° (Fig 6)
Le tour basal est ainsi étalé dans son ensemble

Autres incidences Les incidences de face et trans-orbitaire de Guillen ne sont pas des incidences de choix car elles sectionnent obliquement la cochlée (Fig 7) Par contre pour le promontoire elles sont toutes les deux intéressantes une des coupes effectuée dans chaque incidence l abordera perpendiculairement mais elle explorera une région un peu différente

Limite de visibilité Les tomographies in vivo ont été comparées à des coupes micro-radiographiques de tranches d un millimètre d épaisseur incluses dans du plastique et radiographiées au contact sous une tension de 12 KV

Cette confrontation avait un double but identification des structures étude de la perte des détails en tomographie hypocycloïdale Celle-ci est importante la lame spirale n est jamais visible les bords internes du tube limacéen disparaissent la columelle os poreux donc de plus faible densité n est visible qu à sa base

Conclusion

La recherche d incidences tomographiques étudiées spécialement en fonction de l anatomie propre de la cochlée et associées aux confrontations microradiographiques permettront d aborder plus facilement la pathologie osseuse cochléaire dans les surdités de perception



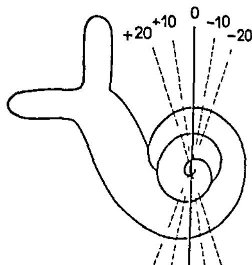


Fig. 5. Balayage tomographique discontinu réalisé avec un tomographe à bras inclinable (Princeps) sur crâne sec.

et le fond du *conduit auditif interne* (Fig. 4, *en haut*). *Une coupe sectionne* le tour basal (Fig. 4, milieu), une autre, enfin, intéresse la fenêtre ovale et le promontoire (Fig. 4, en bas).

L'incidence de Hirtz asymétrique consiste à placer l'axe de la columelle parallèle au film. L'obliquité de l'axe de la columelle par rapport au plan orbito-méatal nécessite de corriger l'incidence de base classique en abaissant d'autant le côté à radiographier.

Le balayage tomographique discontinu après centrage intracrânien serait l'incidence idéale qui sectionnerait la cochlée en rayon de roue, toutes les coupes contenant l'axe de la columelle (Fig. 5).

Cette incidence n'est réalisable actuellement, qu'avec un tomographe à bras inclinable, type craniographe de Dulac. Le sujet est positionné de façon que l'axe de la columelle passe par l'axe de rotation du bras et soit perpendiculaire au plan de rotation.

Des essais réalisés sur crâne sec se montrent encourageants, mais le balayage linéaire de ces appareils n'apporte malheureusement pas la pureté du balayage pluridirectionnel.

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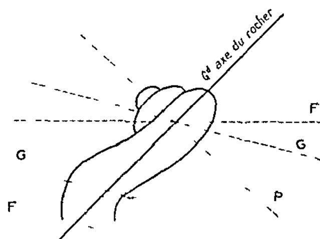


Fig. 7. Orientation des coupes. En incidence de face (F), Guillen (G) et Poschl (P).

RÉSUMÉ

Les incidences tomographiques de la cochlée sont étudiées en fonction de la situation de l'axe de la columelle par rapport au plan sagittal et au plan orbito-méatal. Les tomographies sont comparées avec des microradiographies de coupe anatomique.

SUMMARY

Different projections in tomography of the cochlea were studied as functions of the position of the axis of the columella in relation to the sagittal and orbito-meatal planes. The tomograms were compared with microradiograms of anatomical sections.

ZUSAMMENFASSUNG

Verschiedene Projektionen bei Tomographie der Cochlea wurden mit Hinsicht auf die Lage der Spindelachse im Verhältnis zu den sagittalen und orbito-meatalen Ebenen studiert. Die Tomogramme sind mit den Mikroradiogrammen anatomischer Schnitte verglichen worden.

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FROM THE DEPARTMENTS OF RADIOLOGY AND NEUROSURGERY, DANIEL FREEMAN MEMORIAL HOSPITAL, INGLEWOOD, CALIFORNIA, U S A

THE OCCIPITAL EMISSARY CHANNEL AND INCREASED INTRACRANIAL PRESSURE

by

ERIC T YUHL and ALFRED L SCHMITZ

The normal and abnormal appearances of the vascular channels of the skull have been studied for many years since Schuller's classic publication (1908) LINDBLOM (1936) published an extensive study of this subject and described what he felt were the normal and abnormal appearance of the occipital emissary channel

LINDBLOM *emphasized that the normal canal is 2 mm or less in diameter* Characteristically the channel appears as a funnel or crescent shaped opening at the external occipital protruberance and usually extends downward toward the foramen magnum Occasionally, the channel extends out in another direction

Openings in the occiput may also be observed in association with venous lakes (Fig 1), dermoid cyst (Fig 2), and meningoencephalocele O RAHILLY (1952), in his description of anomalous occipital apertures, states that large openings at normally patent loci, such as the occipital emissary vein, are rare Quoting SPERO, O RAHILLY pointed out that a canal was completely absent in 8 percent of the cases and partially closed in 48 percent of the cases in a study of over 500 skulls We have reviewed 315 consecutive roentgenograms of the skull, taken at the Daniel Freeman Memorial Hospital between January and April 1967, and found only a single instance of a radiologically demonstrable occipital emissary channel

LINDBLOM reported 51 instances of widening of the occipital emissary channel He felt that the blood stream flowing inward is obstructed in increased intra cranial pressure and causes enlargement of the channel and concluded that the



Fig 1 Normal venous lakes in the occipital bones



Fig 2 Occipital opening in a case of dermoid cyst



Fig 3 Hurler's syndrome Large occipital emissary veins intracranial pressure normal

widening was always indicative of general increase in intracranial pressure Other authors (ORLEY 1949, TAVERAS & WOOD 1964) have similarly concluded that the demonstration of these channels may be indicative of increased intracranial pressure

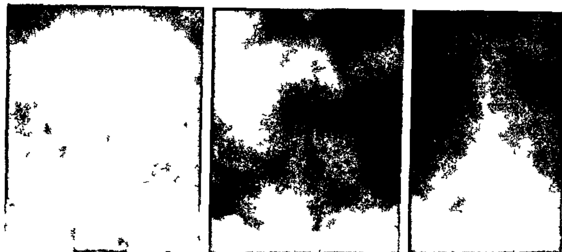


Fig 1 Examples of large occipital emissary channels in normal patients

It is the purpose of this paper to point out that an occipital emissary channel may be demonstrated in the normal patient, is rarely observed in tumor cases, and is of no value as an indicator of the presence of increased intracranial pressure

Our attention was first brought to this problem in a case of Hurler s syndrome (Fig 3) Large anomalous occipital channels were observed on the radiographic films Subsequent complete evaluation failed to reveal general increased intracranial pressure, either of an acute or chronic nature Thereafter, we had occasion to observe the presence of a widened occipital emissary channel in a 43 year old white female who had a history of longstanding dizziness, vertigo, and recent episodes of blackout Increased intracranial pressure was suspected, and the patient was admitted to the hospital Complete evaluation was performed which included spinal puncture and encephalography The intracranial pressure was normal Encephalography revealed minimal cerebral atrophy There was no space consuming intracranial lesion These two patients have been followed for several years Periodic re examination has confirmed the fact that neither patient suffers from increased intracranial pressure

Eight similar cases have since been observed (see Fig 4) Each patient was proved to have normal intracranial pressure

We feel that the size of the emissary channel is of no significance Although the channel is usually small, several of our normal patients had canals in excess of 2 mm in diameter

We have reviewed the last 100 consecutive cases of proved intracranial tumors studied at the Daniel Freeman Memorial Hospital and six additional cases of large posterior fossa tumors in children Many of these patients exhibited general increased intracranial pressure, yet not one had an occipital emissary channel demonstrable on the roentgenograms

SUMMARY

The authors mention that the radiographic observation of an occipital emissary channel particularly one which measures more than 2 mm in diameter has long been felt to indicate increased intracranial pressure In a series of eight patients however in whom such occipital emissary channels were demonstrated the intracranial pressure was normal It is therefore concluded that the radiographic demonstration of an occipital emissary channel regardless of its size is in no way indicative of increased intracranial pressure

ZUSAMMENFASSUNG

Man hat lange angenommen dass die radiographische Darstellung eines occipitalen Ausflusskanals besonders wenn dieser grosser als 2 mm in Diameter ist auf erhohten intrakraniellen Druck deutete Die Verfasser betonen jedoch dass sie in acht Patienten einen occipitalen Ausflussgang radiographisch demonstrieren konnten bei diesen Patienten war aber der intrakranielle Druck normal Die Schlussfolgerung ist dass die radiographische Darstellung eines occipitalen Ausflussganges unabhangig von der Grosse keineswegs ein Zeichen von erhohtem intrakraniellen Druck sei

RÉSUMÉ

On a longtemps pensé que la constatation sur des radiographies d'un canal emissaire occipital en particulier quand il a plus de 2 mm de diametre est un signe d hypertension intracranienne Pourtant huit sujets chez qui on a trouvé de tels canaux émissaires occipitaux avaient une pression intracranienne normale Les auteurs pensent que la mise en évidence radiographique d un canal emissaire occipital quel que soit son diamètre n est en aucune façon le signe d une hypertension intracranienne

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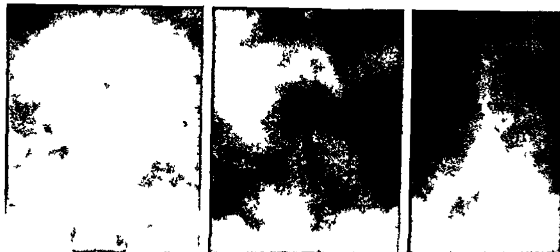


Fig 4 Examples of large occipital emissary channels in normal patients

It is the purpose of this paper to point out that an occipital emissary channel may be demonstrated in the normal patient, is rarely observed in tumor cases, and is of no value as an indicator of the presence of increased intracranial pressure

Our attention was first brought to this problem in a case of Hurler s syndrome (Fig 3) Large anomalous occipital channels were observed on the radiographic films Subsequent complete evaluation failed to reveal general increased intracranial pressure, either of an acute or chronic nature Thereafter, we had occasion to observe the presence of a 'widened occipital emissary channel in a 43 year old white female who had a history of longstanding dizziness, vertigo, and recent episodes of blackout *Increased intracranial pressure was suspected, and the* patient was admitted to the hospital Complete evaluation was performed which included spinal puncture and encephalography The intracranial pressure was normal Encephalography revealed minimal cerebral atrophy There was no space consuming intracranial lesion These two patients have been followed for several years Periodic re examination has confirmed the fact that neither patient suffers from increased intracranial pressure

Eight similar cases have since been observed (see Fig 4) Each patient was proved to have normal intracranial pressure

We feel that the size of the emissary channel is of no significance Although the channel is usually small, several of our normal patients had canals in excess of 2 mm in diameter



Fig 1 a) Coronal tomogram of normal medulla oblongata Air in the medullary cistern outlines the medulla (arrows) slight asymmetry of the medulla as in this case is frequently seen b) Coronal tomogram of glioma of the medulla (arrows) A markedly enlarged medulla compresses the cisterns between the tumor and the medial margins of the cerebellar tonsils



Fig 2 a) Sagittal tomogram of the normal medulla oblongata The clava of the posterior portion of the medulla is shown (lower arrow) this produces a characteristic slight displacement posteriorly of the air column Often the first portion of the lateral recess of the fourth ventricle can be seen (upper arrow) b) Glioma of the medulla with more caudal infiltration than in fig 1b The posterior displacement of the air column is more marked (arrow) as compared to fig 2a. The upper cervical cord and the anterior margin of the tumor are visible (crossed arrow)

is usually achieved Fluid levels often persist and we feel that it is necessary with drainage of fluid prior to the injection of air Approximately 10 ml fluid is withdrawn in a child and exchanged with air and for an adult up to 20 ml is exchanged

If the high cervical cord and foramen magnum area is to be demonstrated the neck should be craned forward and the head further flexed so that the clivus is almost horizontal

PNEUMOGRAPHY

POSTERIOR FOSSA TOMOGRAPHY DURING ENCEPHALOGRAPHY

by

JOHN ALBERTI, JOHN ANDREWS and GABRIEL WILSON

The encephalographic diagnosis of posterior fossa disease may be difficult with standard procedures Lateral upright autotomography for demonstration of the fourth ventricle and aqueduct is now virtually a routine addition to the standard technique

Some authors have questioned the value of mechanical tomography in supra tentorial lesions but most would agree that posterior fossa disease can be de monstrated in greater detail by tomography

Technique

The basic technique for encephalography using the Mimer is that described by FREDZELL & LINDGREN (1960) and LINDGREN & MATTSSON (1965) This unit provides linear coronal or sagittal tomography with the patient erect or recum bent at any time during the course of encephalography For tomography the head and neck are flexed further forward so that the foramen of Monro will be 3 to 4 mm below the level of junction of the aqueduct and third ventricle This position will trap air in the fourth ventricle and aqueduct for a prolonged period of time and thus allow tomography to be performed

After one or two increments of 7 to 10 ml of air are injected, a good de monstration of the subarachnoid space, including the superior cerebellar cistern,

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On the posterior portion of the medulla just below the foramen of Magendie a slight posterior deviation of the air column is frequently seen This swelling of the medulla oblongata is due to the clava of the medulla and is seen in the sagittal tomograms (Fig 2)

Conclusion

Tomography in the coronal and sagittal planes with the patient erect is a valuable adjunct to encephalography It must be readily available and mechanically simple so that the roentgen examination is not unduly prolonged

SUMMARY

The authors experience with posterior fossa tomography in a material of 137 cases is described It was found that additional information could be obtained in 75 % of cases as compared to the results obtained with routine techniques

ZUSAMMENFASSUNG

Die Verfasser berichten kurz uber ihre Erfahrungen mit Tomographie der hinteren Schadelgrube bei 137 Fallen. In 75 Prozent der Falle erhielt man zusatzliche Information im Vergleich zu den mit der gewohnlichen Technik erreichbaren Resultaten

RÉSUMÉ

Les auteurs decrivent leur experience de la tomographie de la fosse postérieure sur une serie de 137 cas de pneumo-stratigraphie Ils ont constate que dans 75 % des cas la tomographie apporte des renseignements supplementaires par rapport aux techniques habituelles

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Our material has been taken from 410 consecutive encephalographic examinations. Posterior fossa tomography was used in 137 cases. An analysis of the value of the mechanical tomograms over routine techniques, including autotomography, showed that additional information was gained in approximately 75 per cent of the cases. Of this group, the information was estimated to be essential to a correct diagnosis in one third of the cases. The total of 137 cases were divided into 69 cases with no encephalographic evidence of posterior fossa disease, 30 cases with atrophic processes, 28 with tumor, and 10 cases with miscellaneous diseases.

Roentgen findings

For detailed anatomical descriptions of the posterior fossa the reader is referred to several scientific works (LILIEQUIST 1959, DI CHIRO 1961, HUANG & WOLF 1967).

Coronal sections. The cerebellar tonsils are often asymmetric. When seen in the coronal tomograms, one tonsil can appear larger than the other so that the vallecula is displaced from the midline. Normally the vallecula maintains its vertical direction. *The inferior aspect of the tonsils should always be at or above the rim of the foramen magnum.*

Slight rotation of the head may produce an asymmetrical appearance of the medulla oblongata. The normal protuberances of the medulla are the pyramids ventrally, the inferior olives on the ventro-lateral side, and the inferior cerebellar peduncles (restiform body) at the dorso-lateral side. Slight rotation of the head may accentuate these structures giving the false impression of a tumor. This is more marked in routine p.a. films, but even in the tomograms in the coronal plane slight asymmetry of the medulla is not unusual and should not be mistaken for abnormality (Fig. 1).

Sagittal sections. The height of the fourth ventricle as seen in the sagittal tomograms should be taken from the floor to the fastigium. A point of possible error is the posterior superior recess which extends inferiorly and laterally from the fastigium (AMUNDSEN & GRIMSRUD 1966). *In the midline tomogram, the fastigium is clearly defined if it is in normal position, but the posterior superior recesses are blurred since they are more lateral.*

Also in the sagittal tomograms of children a large cisterna magna is frequently demonstrated with a short and broad vallecula leading into the foramen of Magendie. This has been considered evidence of atrophy of the inferior vermis (ROBERTSON 1967). We believe this is a normal finding unless there is other evidence of atrophy, such as a large fourth ventricle or a prominent superior cerebellar cistern.



a b c

Fig 1 a) Sagittal tomography The patient is well supported and strapped A pad between the table and the head insures correct sagittal positioning of the latter b) Frontal view c) The lower part of the back is kept slightly away from the table so that the lumbar puncture remains in situ



a b

Fig 2 a) Lateral brow up position after the chair has been removed b) Sagittal tomography in brow up position

to produce tomograms A tomogram of a specimen embedded in a dry skull together with a normal control provide excellent examples of anatomic detail, dissection of the preparation helps to identify the separate structures

Two factors are important in obtaining optimum detail thin tomographic cuts and meticulous gas filling Hypocycloidal movement of the polytome appears to

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GAS ENCEPHALOGRAPHY WITH HYPOCYCLOIDAL TOMOGRAPHY

Correlation with anatomic casts

by

P AMUNDSEN, P DUGSTAD and O K GRIMSRUD

Tomography with hypocycloidal movement of the polytome provides remarkably clear anatomic detail in gas encephalography The apparatus is however not built for this examination and an additional chair is required, the encephalographic technique must also be slightly modified A simple and effective chair is illustrated in Fig 1a, this can be easily attached to the polytome table and is movable in all directions so that the patient may be positioned for lateral as well as frontal tomography The gas insufflation is performed with the patient positioned for sagittal tomography the filling being checked with midline tomograms, the patient is then carefully turned to the frontal position (Fig 1, b and c) and a series of frontal tomograms obtained Routine survey films and additional tomograms follow with the table horizontal — lateral views require another roentgen tube (Fig 2a) — and for sagittal tomography in the brow up position the patient is placed upon a special trolley (Fig 2b) Tomographic cuts of the brain and the adjacent skull depict the cisternal spaces and their relationship to the bony structures far better than routine anatomic specimens Special preparations were made for comparative study The cisterns and ventricles were filled with 'silopren' in intact cadavers, the brain with the cast attached was then removed and fixed in formalin Some of the specimens were embedded in a cast of green coloured silopren, which in cuts represents the dura covered brain Other specimens were placed in a dry skull of suitable size

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RADIOGRAPHIC DEMONSTRATION OF CORTICAL HETEROTOPIA

by

R THOMAS BERGERON

Cortical gray matter may be found in an ectopic position in the mature brain as a consequence of migrational arrest of primitive nerve cells (*neuroblasts*) during fetal development (OSTERTAG 1956 SCHOB 1930) The exact factors (such as environmental and genetic) responsible for this arrest have not been entirely defined On the basis of experimental work, however it may be presumed that an environmental insult sustained by the fetus during development of the cortex (i e between the 3rd and 5th fetal month) may be the responsible agent in at least some instances occurring clinically (COWEN & GELLER 1960)

Varying degrees of migrational arrest of the neuroblasts result in aggregates of dysplastic heterotopic cortex either in the centrum semiovale (incomplete arrest) or at the embryologic site of origin of the neuroblasts just beneath the ependyma (complete arrest) The presence of these clumps of heterotopic gray matter beneath the ependyma will deform the lateral ventricular surfaces (Fig 1) as such, they are demonstrable at cerebral pneumography (Fig 2)

Cortical heterotopias of sufficient size to be grossly obvious at either cerebral pneumography or at autopsy never occur in the absence of other significant structural abnormalities.



Fig. 3. a) Tomogram of specimen embedded in a dry skull. b) Tomogram during gas encephalography at the same level.

produce the best tomograms. Premedication with 'dropendol' decreases vomiting and helps considerably in attaining complete gas filling of the cisterns as well as the ventricles.

SUMMARY

The employment of hypocycloidal tomography in gas encephalography is described. Special preparations are used to correlate anatomic specimens with the tomograms.

ZUSAMMENFASSUNG

Die Anwendung der hypocycloidalen Tomographie in Gasencephalographie wird beschrieben. Besondere Präparate wurden benutzt um die anatomischen Proben mit den Tomogrammen zu korrelieren.

RÉSUMÉ

Description de l'utilisation de la tomographie hypocycloïdale dans l'encéphalographie gazeuse. Les auteurs ont utilisé des préparations spéciales pour confronter les pièces anatomiques et les tomographies.



Fig 2 Pneumographic appearance of subependymal cortical heterotopias p a projections a) Broad based nodules arising from the lateral walls no calcifications are present the third ventricle was normal b) Combined encephalogram ventriculogram one year after ventriculo-atrial shunt the masses are virtually unchanged in appearance (Autopsy confirmed the presence of these cortical heterotopias it also revealed a clinically diagnosed congenital aqueductal stenosis.)

In addition to these features it was found that all of these subjects had died during childhood and that, while one lived till the age of 8 years most died before the age of one year

A review of the cerebral pneumograms of over 60 cases of serious structural abnormalities of the brain showed five cases with pneumographic evidence of cortical heterotopia Two of these cases subsequently had autopsy confirmation These five cases had in addition to the cortical heterotopias the following structural defects (1) distortion of normal cortical architecture (microcephaly) 2/5 (2) maldevelopment of the corpus callosum 4/5 (3) cerebellar dysgenesis 1/5 (4) stenosis of the aqueduct of Sylvius 1/5 (5) other bodily anomalies 2/5 and (6) psychomotor retardation 5/5

The similarity between the clinically obtained material and the autopsy material is striking

On the basis of a review of the clinical records autopsy material and radiographic findings the following criteria have been established for the pneumographic diagnosis of subependymal heterotopic cortical gray matter

1 Subependymal heterotopic cortical gray matter will manifest itself by nodular deformity of the lateral ventricles The third ventricle aqueduct of Sylvius and fourth ventricle will not be involved since development of the cortex is a forebrain phenomenon

2 The nodules usually have broad bases They may be single or multiple

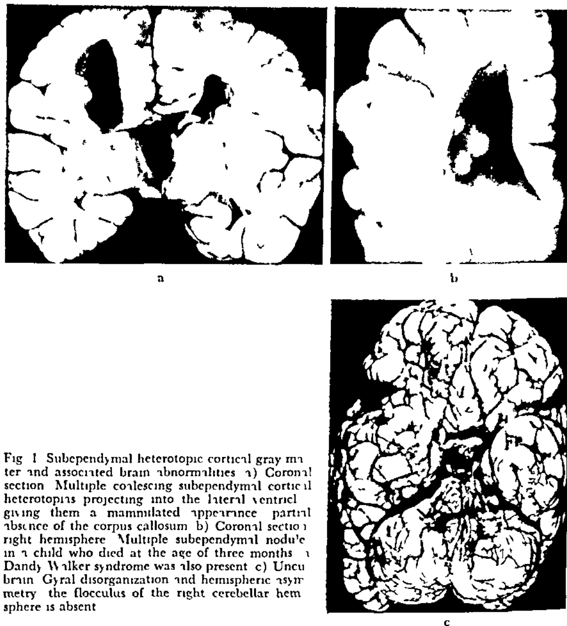


Fig 1 Subependymal heterotopic cortical gray matter and associated brain abnormalities a) Coronal section Multiple coalescing subependymal cortical heterotopias projecting into the lateral ventricle giving them a mammillated appearance partial absence of the corpus callosum b) Coronal section right hemisphere Multiple subependymal nodule in a child who died at the age of three months a Dandy Walker syndrome was also present c) Uncut brain Gyral disorganization and hemispheric asymmetry the flocculus of the right cerebellar hemisphere is absent

A tabulation of ten cases with gross subependymal cortical heterotopia at autopsy performed at the Columbia Presbyterian Medical Center and the New York Neurological Institute has revealed the following features (1) distortion of normal cortical architecture (microgyria, pachygyria arrhinencephaly 8 10 (2) maldevelopment of the corpus callosum (partial or complete agenesis) 8 10, (3) cerebellar anomalies 5/10, (4) congenital stenosis of aqueduct of Sylvius 5/10, (5) other bodily anomalies 7/10, and (6) psychomotor retardation 10/10



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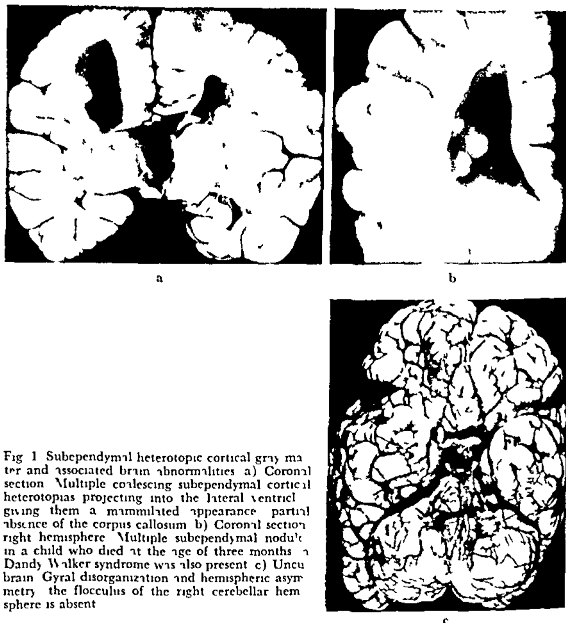


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they may coalesce, giving a mammilated surface to the wall They usually arise from the roofs or lateral aspects of the ventricles In two cases, wherein they arose medially, they were in the region of the atria and could not be distinguished pneumographically from choroid plexus

3 The nodules do not calcify, calcification in other areas of the brain is not a feature of the entity

4 The nodules do not significantly change upon re examination of the subject, as may be seen with neoplastic, inflammatory, or parasitic processes

5 Other congenital anomalies of the brain are unfailingly present, in rare instances this may be difficult to demonstrate pneumographically (e g microgyria)

6 Congenital anomalies of other organ systems will be noted concomitantly in many instances

7 All cases will show varying degrees of psychomotor retardation clinically

From a practical point of view, it may be seen that the entity most important to be distinguished from cortical heterotopia is tuberous sclerosis (KAPP et coll 1967) Both processes are seen in retarded children and may be characterized by subependymal nodules within the lateral ventricles The criteria enumerated above may help to distinguish between the two

Less commonly, the clinical problem may arise wherein cortical heterotopias are misdiagnosed as neoplastic processes In these instances, the pneumographic identification is important in order to circumvent needless surgical or radiotherapeutic maneuvers

In all instances, their identification is of value in that their presence is a reliable index of severe structural abnormality of the brain These subjects may be relied upon to exhibit considerable impairment in both motor and intellectual development

Acknowledgements

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SUMMARY

Subependymal heterotopic cortical gray matter arises as a result of migrational arrest of primitive neuroblasts during fetal development A review of the clinical autopsy and cerebral pneumographic records of subjects with this entity has been conducted The combination of other structural brain defects psychomotor retardation and certain morphologic features of subependymal heterotopic cortical gray matter permits their pneumographic identification in the ante mortem state

ZUSAMMENFASSUNG

Das subependymale heterotopische Vorkommen der corticalen grauen Substanz wird durch den Stillstand der Migration des primitiven Neuroblastes wahrend der fetalen Entwicklung verursacht Ein Durchgang klinischer und cerebral pneumographischer Daten und der Autopsie Befunde bei diesen Anomalien wurde vorgenommen. Die pneumographische Identifikation dieser Entwicklungsstorungen im Lebenden kann durch eine Kombination von Beobachtungen struktureller Gehirndefekte psychomotorischer Verzogerungen und gewisser morphologischer Aspekte der subependymal und heterotopisch vorkommenden corticalen grauen Substanz ermoglicht werden

RÉSUMÉ

La presence de matiere grise corticale hétérotopique sous-ependymaire est le resultat d un arret de migration des neuroblastes primitifs au cours du development foetal L auteur présente les resultats de l examen clinique de l autopsie et de l encephalographie gazeuse des malades atteints de cette affection L association a d autres malformations cérébrales a un retard psycho-moteur et certains caractères morphologiques d la matiere grise corticale hetérotopique sous ependymaire permet de faire le diagnostic encéphalographique du vivant

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NITROUS OXIDE AND OXYGEN AS CONTRAST MEDIUM IN PNEUMOGRAPHY UNDER GENERAL ANAESTHESIA

by

K BERGSTROM, S HOGSTROM and H LODIN

Instead of using air for encephalography, both oxygen and different anaesthetic gases have been tried as contrast medium in an attempt to cause fewer after effects, such as headache and the like The absorption properties of the gases are *of special interest as it has been claimed that prolonged symptoms after encephalography* can be correlated to the slow rate of absorption

AIRD (1937) tested eight different gases in dogs, and of these nitrous oxide and ethylene proved to be particularly promising In a clinical series, this author compared air, oxygen, ethylene and nitrous oxide, of which the latter was found to be absorbed most quickly, approximately 90 % disappearing within 5 hours Ethylene was absorbed slightly slower, while air had a long disappearance time, about 50 % *having disappeared at 30 hours Oxygen was absorbed somewhat* more rapidly, and within 30 hours almost 90 % was cleared The subjective symptoms after nitrous oxide and ethylene were considerably less marked than after air The anaesthetic gases mentioned were well tolerated and produced a sedative effect, which was regarded as an advantage AIRD considered nitrous oxide to be less suitable since it was absorbed so rapidly that there was not always time to complete the investigation if it extended over a fairly long period of time He therefore recommended ethylene as the more suitable contrast medium

Not only the after effects of encephalography and the absorption properties of the gas are of importance, however, in the selection of a suitable contrast medium SAIDMAN & EGER (1965), in air encephalography performed with nitrous oxide as the anaesthetic in four animal experiments, as well as in three encephalographic *examinations of human subjects, demonstrated that an increased*

supply of nitrous oxide in the respiratory tract resulted in a rise in pressure of the cerebrospinal fluid This pressure increase may be explained by the low solubility of nitrogen in blood compared with nitrous oxide, nitrogen being about 30 times less soluble This means that nitrous oxide molecules pass into the air filled part of the ventricular system while only a few nitrogen molecules leave it Since the brain is enclosed by the rigid cranium no expansion can take place and the increase in the number of gas molecules will be expressed in the form of a pressure increase On the other hand a rapid elimination of the nitrous oxide occurs when the anaesthesia is discontinued or if this gas is withdrawn from the inhaled gas mixture, and the cerebrospinal fluid pressure is then reduced These authors also stated that when nitrous oxide instead of air as contrast medium was used no pressure increase occurred They suggested that the risk of serious complications would be less if this rapidly absorbable gas is employed

The observations of the last mentioned authors appear to be of clinical importance in at least two respects First in patients who already before the examination have a raised intracranial pressure a further increase during pneumography under nitrous oxide anaesthesia can be avoided if this gas is used also as contrast medium With general anaesthesia some risk of pressure increase exists already since the commonly used complementary anaesthetic agents halothane and methoxyfluorane have a depressive effect on the respiration with a tendency to produce carbon dioxide retention (HOLMDAHL & PAYNE 1960 DOBKIN & FEDORUK 1961 BLACK & MCKANE 1965 NGAI et coll 1965) If both carbon dioxide retention and nitrous oxide anaesthesia in pneumography contribute to a further rise in intracranial pressure the risk of compression is increased

Secondly the relatively rapid absorption of the nitrous oxide from the cerebrospinal fluid spaces after discontinuation of the anaesthesia constitutes a great advantage in cases of hydrocephalus in which a shunt operation to relieve the condition is desirable as soon as possible after pneumography

In consideration of the facts just related we have during the last six months used the same nitrous oxide and oxygen mixture as the patient has inhaled as contrast medium in pneumographies performed under general anaesthesia with nitrous oxide and oxygen as the basic anaesthetic agent

Examination technique

Anaesthesia The examinations in all the cases recorded were performed under general anaesthesia, which in adults was induced with an intravenous barbiturate after preliminary oxygen inhalation The patient was intubated after the injection of succinylcholine, and the respiration was then controlled until spontaneous breathing returned Nitrous oxide and oxygen together with small quantities of

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absorption time was less than 48 hours For a series of 14 air encephalographies the time was 7 days

No definite influence of the gas injection on the circulation or respiration was observed Because of a possible respiratory depression blood gas analyses were performed before discontinuation of the anaesthesia A very small increase in the pCO values was noted in the fourteen patients who underwent encephalography or ventriculography with nitrous oxide and oxygen as contrast medium under nitrous oxide and oxygen plus methoxyfluorane anaesthesia The observed increase was no greater however than the increase which occurred in patients operated on for other reasons under the same form of anaesthesia (see Table 2)

A faint impression that the depth of anaesthesia was somewhat increased temporarily on injection of the nitrous oxide and oxygen mixture was not confirmed objectively The return to consciousness of these patients after the investigation did not differ from other patients given the same kind of anaesthesia Two patients did not wake up as soon as might have been expected but in these the methoxyfluorane anaesthesia was unusually prolonged Furthermore these were ventriculographies in which the ventricular system was closed, and it is not known whether the patients would have reacted in the same way after air ventriculography performed during anaesthesia of the same kind

Discussion

The method described in which the same gas mixture of nitrous oxide and oxygen as was used for the general anaesthesia, was employed as contrast medium in cerebral pneumography was found to be well tolerated by the patient The absorption time was considerably shorter than when air is used Direct comparison with the results obtained by AIRD has not been possible but the absorption time appeared to be longer in our series probably due to the fact that the nitrous oxide mixture that we used was not pure No technical difficulties due to too rapid gas absorption from the ventricular system were met with in the examinations It may be mentioned that AIRD's patients breathed air during the investigation and an absorption promoting concentration gradient existed consequently during the entire period between the nitrous oxide filled ventricular system and the surrounding tissue and blood

No pressure measurements in the cerebrospinal fluid space have as yet been made but are being planned The usefulness of such measurements has become evident on analysis of the experimental results now obtained

Nitrous oxide and oxygen in the cerebrospinal fluid space appeared to cause no increase in carbon dioxide tolerance in comparison with similar forms of anaesthesia in patients undergoing other operations If the reduction in body

the complementary anaesthetic agent, viz. halothane or methoxyfluorane, were administered during this phase. As a rule, a partial re-breathing system, with a carbon dioxide absorber included, was used in adults. The oxygen content in the gas mixture administered was generally about 25 % but in older subjects just over 30 % was preferred (3 liter N_2O+1 liter O_2 or 2 liter N_2O+1 liter O_2 per minute). The nitrous oxide and oxygen mixture passed through a vaporizer, containing either halothane or methoxyfluorane, placed outside the circuit system.

The anaesthesia was in children often induced with nitrous oxide and oxygen plus halothane, followed by intubation when a sufficient depth of anaesthesia had been obtained. In older children, succinylcholine was given before intubation, as in adults.

The aim was to keep the anaesthesia as light as possible, and the amount of the complementary anaesthetic agent was determined according to the clinical indications on the depth of anaesthesia in relation to the degree of stimulation during the different stages of the investigation. By a series of blood gas analyses at the discontinuation of the anaesthesia, a good idea has been obtained of how best to achieve anaesthesia technically without producing a too marked carbon dioxide retention.

The gas tension and the acid-base condition in the arterial blood were checked before the anaesthesia was discontinued in several patients who underwent roentgenologic examination. In these instances, the anaesthesia was generally prolonged, the average duration was three hours, none was shorter than one hour and in some cases the anaesthesia lasted for over six hours. The carbon dioxide retention was measured on a radiometer commercial pCO_2 electrode, thermostatically controlled at 38° C. The analyses were usually performed immediately after the samples had been taken.

Gas mixture for cerebral pneumography. It seemed logical to use as contrast medium the same nitrous oxide and oxygen mixture as the patient had inhaled. A shunt tube was therefore attached to the anaesthetic machine. From this tube, which could easily be connected, a syringe was filled with the gas mixture, which was then immediately injected through the lumbar or ventricular puncture needle. The roentgenologic examination was performed in the usual manner. The gas absorption was checked by daily roentgen examinations until complete absorption had occurred.

Results

The method was used in 19 instances, comprising 10 encephalographies and 9 ventriculographies. The absorption times are given in Table 1. The mean

This gas mixture is relatively rapidly eliminated from the ventricular system after the investigation which makes it possible to continue earlier with a shunt operation than when air is used No disadvantage has been observed when using the method now described

SUMMARY

A nitrous oxide and oxygen mixture was employed both as a general anaesthetic and as contrast medium in a series of 19 cerebral pneumographies The preliminary results indicate that the procedure is well tolerated no increase in the carbon dioxide retention or in the intracranial pressure occurs and the contrast medium is rapidly absorbed

ZUSAMMENFASSUNG

Eine Mischung von Sauerstoff und Lachgas wurde als generelles Betaubungsmittel sowie als Kontrastmittel in einer Serie von 19 pneumographischen Gehirnuntersuchungen benutzt Die preliminaren Resultate zeigen dass die Methode gut vertragen wird keine Anreicherung von Kohlensaure stattfindet der Gehirndruck normal bleibt und das Kontrastmittel schnell absorbiert wird

RÉSUMÉ

Les auteurs ont utilise un melange de protoxyde d azote et d oxygene à la fois comme anesthesique general et comme moyen de contraste au cours de 19 pneumographies cérebrales Les resultats preliminaires montrent que cette technique est bien toleree qu elle ne provoque ni augmentation de la retention de gaz carbonique ni elevation de la pression intracranienne et que l absorption du moyen de contraste a lieu rapidement

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Table 1

Absorption times for the nitrous oxide and oxygen mixture used in encephalography and ventriculography

	Total number	< 1 day	< 2 days	< 3 days	< 4 days	< 5 days	< 8 days
Encephalography	10	6	3	—	—	—	1 (air mixture)
Ventriculography	9	3	2	3	—	1	—

Table 2

Blood gas analyses in 14 patients undergoing examination under nitrous oxide and oxygen plus metho fluorane anaesthesia (pCO_2 mm Hg in the arterial blood at 38° C)

	Number of patients	Mean value	Standard deviation	Standard error of mean
Cerebral pneumography with $N_2O + O_2$	14	45.5	± 6	± 1.5
No pneumography	18	48	± 6	± 1.5

temperature during a prolonged anaesthesia is taken into account, the slight increase in the carbon dioxide tension is still smaller. It seems reasonable to assume that the body temperature of these patients lay between 35° and 36° C, which would mean that the pCO_2 values were scattered around a mean value of 40 to 42 mm Hg, i.e. normal values for the carbon dioxide pressure. Sometimes, however, a definite pCO_2 increase occurred.

We have preferred, in choosing between different contrast media, not to use an entirely oxygen free mixture. Pure oxygen may be considered but its absorption time is considerably longer. Whether the pressure increase observed by CRONQVIST et coll. (1963) on injection of oxygen into the subarachnoid space or the ventricular system may be due to the use of oxygen or whether it would occur also with other contrast media is not known. This question can be answered only by pressure studies.

Conclusion

The increase in volume of the gas within the cranium with consequent rise in pressure that may occur when air is used as contrast medium in pneumography performed under nitrous oxide and oxygen anaesthesia, may be prevented if this same mixture of gases is used in place of the air in the cerebrospinal fluid space.

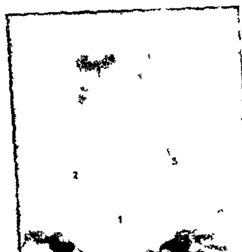


Fig 1 Vallecule dilatee et citerne vermienne inferieure (1) amputation de la citerne ambiante droite (2) deformation de la citerne ambiante (3) et absence d insufflation de la citerne pericalleuse droite (4)



Fig 2 Vallécule dilatée (1) vermis inferieur (2) citernes ponto-cerebelleuses et laterobulbaire dilatees (3) citerne circumpédonculaire gauche (4) deformée par la hernie temporale et citerne ambiante droite disloquee (5)

Observations

Cas 1 Jeune fille de 9 ans admise pour hypoacousie bilatérale cephalees vomissements *et crises convulsives*

A l examen légere raideur de la nuque paralysie de la 4eme paire cranienne a droite stase papillaire bilaterale troubles de la sensibilité profonde du membre superieur gauche et somnolence progressive

EEG foyer parieto-occipital droit Encéphalographie gazeuse fractionnee (Fig 1) montrait une dilatation de la vallecule *et de la citerne* vermienne inferieure amputation de la citerne ambiante a droite déformation en *« S » italique de la* citerne ambiante gauche et absence d insufflation de la citerne pericalleuse droite

Comptes rendus opératoire et histologique enorme astrocytome kystique occupant presque la totalite de l hémisphere cerébral droit

Cas 2 Femme agee de 50 ans Hemiplegie droite lentement progressive avec quelques troubles aphasiques stase papillaire bilaterale

EEG foyer fronto-rolandique gauche Encephalographie (Figs 2 et 3) absence d insufflation du systeme ventriculaire dilatation *de la vallecule* de la citerne ponto-cerebelleuse et laterobulbaire a droite deformation de la citerne circumpedonculaire gauche traduisant une hernie temporale dislocation des *differents segments* de la citerne ambiante droite et dilatation du sillon post pyramidal

Les modifications cisternales de la fosse posterieure quoique indirectes traduisent la présence d une masse sus tentorielle compliquee d une hernie temporale gauche

SERVICE CENTRAL DE RADIOLOGIE DU C. H. U. DE STRASBOURG (DIRECTEUR PROF. CH. M. GROS) ET SERVICE DE NEURO-RADIOLOGIE DU C. H. R. DE COLMAR (DIRECTEUR J. P. BRAUN), FRANCE

HYDROCÉPHALIE EXTERNE ACTIVE DE LA FOSSE POSTÉRIEURE

par

J. P. BRAUN, C. VROUSOS et J. BAUMGARTNER

L'encéphalographie gazeuse fractionnée, grâce aux informations ventriculaires et cisternales qu'elle apporte, permet le diagnostic de localisation d'un processus expansif intra-crânien dans la majorité des cas. Parfois, les signes ventriculaires sont absents et nous nous trouvons seulement en présence d'une cisternographie pour orienter ce diagnostic.

SCHECHTER, BULL & CAREY, en 1958, ont décrit la dilatation de la citerne péricalleuse et des citernes ambiantes dans l'hypertension de la fosse postérieure par tumeur. ROTH, en 1963, a repris ces études en insistant sur le mécanisme de la hernie transtentorielle du cervelet.

Dans un précédent travail, l'un de nous a rapporté les anomalies de la citerne de la grande veine de Galien dans les processus expansifs sus- et sous-tentoriels permettant un diagnostic de localisation en cas d'obstruction du trou de Magendie au cours de l'encéphalographie gazeuse.

Cependant, dans un certain nombre de cas, cette citerne n'est pas insufflée de sorte qu'on se heurte à des difficultés d'interprétation. C'est à ce moment qu'un certain nombre d'anomalies cisternales permettent un diagnostic d'orientation, c'est en rapportant quelques observations démonstratives que nous allons essayer d'illustrer ce phénomène.



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Cas 1 Jeune fille de 9 ans admise pour hypoacousie bilaterale cephalées vomissements et crises convulsives

A l examen légere raideur de la nuque paralysie de la 4eme paire cranienne a droite stase papillaire bilaterale troubles de la sensibilite profonde du membre superieur gauche et somnolence progressive

EEG foyer pariéto-occipital droit Encéphalographie gazeuse fractionnee (Fig 1) montrait une dilatation de la vallecule et de la *citerne vermienne inférieure* amputation de la citerne ambiante a droite deformation en « S » italique de la citerne ambiante gauche et absence d insufflation de la citerne pericalleuse droite

Comptes rendus opératoire et histologique enorme astrocytome kystique occupant presque la totalite de l hemispher cérébral droit

Cas 2 Femme agee de 30 ans *Hémiplegie* droite lentement progressive avec quelques troubles aphasiques stase papillaire bilatérale

EEG *foyer fronto*-rolandique gauche Encephalographie (Figs 2 et 3) absence d insufflation du system ventriculaire dilatation de la vallecule de la citerne ponto-cerebelleuse et latérobulbaire a droite deformation *de la* citerne circumpedonculaire gauche traduisant une hernie temporale dislocation des differents segments de la citerne ambiante droite et dilatation du sillon post pyramidal

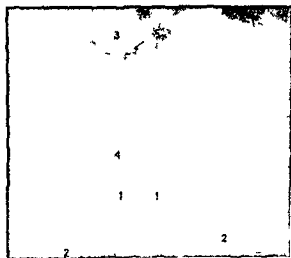
Les modifications cisternales de la fosse postérieure quoique indirectes traduisent la presence d une masse sus tentorielle compliquee d une hernie temporale gauche



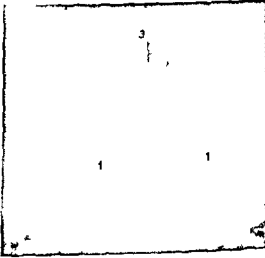
Fig. 3. Pneumostratigraphie sagittale médiane de la fosse postérieure. Refoulement et redressement de la plaque quadrigéminale (1), refoulement de la citerne prévermienne (2) et dilatation du sillon post-pyramidal (3).



Fig. 4. Dilatation de la citerne de la crête occipitale droite (1), dilatation de la citerne péricalleuse (2) et refoulement de la citerne ambiante gauche.



a



b

Fig. 5. Incidences fronto-sous-occipitale assise avec rayonnement horizontal (a) et avec décalage ascendant de 30° du rayonnement (b). Citerne de la crête occipitale dilatée (1), citerne crurale (2), citerne péricalleuse (3) et 4ème ventricule (4).

Comptes rendus opératoire et histologique : glioblastome multiforme infiltrant la région rolandique gauche.

Cas 3. Jeune femme de 20 ans admise pour vomissements, céphalées, troubles visuels et syndrome cérébelleux cinétique ; flou papillaire bilatéral.

EEG : altérations diffuses. On voyait sur l'encéphalographie gazeuse fractionnée (Fig. 4) la dilatation de la citerne de la crête occipitale droite, de la citerne péricalleuse



Fig 6 Vallecule dilatée et deviee (1) soulevement et compression des citernes crurale et latero-pontique (2) écartement des citernes ambiantes (3) et dilatation des citernes sus-cerebelleuses et pericalleuses (4)



Fig 7 Vallecule dilatee (1) citerne de la crete occipitale droite dilatee (2) citerne pontocerebelleuse gauche dilatee (3) citerne ambiante gauche deformée (4) citerne ambiante droite dilatee (5) dilatation des ailes laterales (6) dilatation de la citerne pericalleuse (7) et calcifications tumorales (8)

Comptes rendus operatoire et histologique astrocytome kystique du lobe cerébelleux gauche

Cas 4 Petit garçon de 3 ans admis pour vomissements et cephalées évoluant depuis deux mois syndrome cerebelleux statique et cinetique a prédominance droite oedeme papillaire

La radiographie du crane montrait une distension des sutures avec augmentation du volume cranien Encephalographie gazeuse fractionnee (Fig 5) dilatation diffuse des cavites ventriculaires dilatation des citernes des cretes occipitales surtout a gauche dilatation des citernes crurales prédominante a gauche et dilatation de la citerne pericalleuse

Intervention et examen histologique astrocytome kystique du lobe cérebelleux droit adhérant en haut à la tente du cervelet s etendant en dedans jusqu au 4eme ventricule et en avant au mesencephale Le 4eme ventricule est permeable

Cas 5 Homme de 66 ans admis pour cephalees vomissements et troubles de la marche A l examen hypoacousie bilaterale a predominance gauche nystagmus battant vers la droite et troubles cerebelleux

Encephalographie gazeuse fractionnee (Fig 6) dilatation et deviation de la vallecule ecartement des citernes ambiantes ecrasement de la citerne inter pedonculaire bascule du tronc cérebral vers la droite soulevement de la citerne crurale et latero-pontique gauche et dilatation des citernes du vermis supérieur et des citernes pericalleuses

Comptes rendus opératoire et histologique neurinome du nerf acoustique gauche de la taille d un oeuf de poule ayant fortement refoule le lobe cerebelleux

Cas 6 Garçon de 10 ans admis pour cephalees troubles cérebelleux cinetiques paralysie facial droite nystagmus horizontal signe de Kernig bilatéral

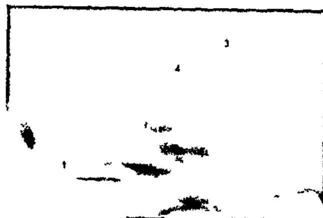


Fig. 8. Grande citerne (1), citerne du velum interpositum dilatée (2), citerne susquadrigéminale déformée (3) et calcifications tumorales (4).

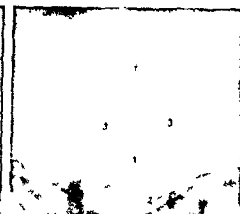


Fig. 9. Vallécule dilatée (1), citernes latéro- et prébulbaires dilatées (2) et citernes dilatées des crêtes occipitales (3).

Examen encéphalographique (Figs. 7 et 8) : dilatation de la vallécule, de la citerne de la crête occipitale droite et de la citerne ponto-cérébelleuse gauche, déformation et compression de la citerne gauche, dilatation de la partie supérieure de la citerne ambiante droite, dilatation des ailes latérales des citernes ambiantes et péricalleuses, et calcification tumorale.

Comptes rendus opératoire et histologique : médulloblastome du vermis avec extension vers l'hémisphère cérébelleux droit.

Cas 7. Petite fille de 6 ans admise pour céphalées, fatigue, troubles de la marche.

A l'examen, on notait une hypotonie et une inclinaison de la tête vers le côté gauche, nystagmus battant vers la gauche dans le regard latéral.

Encéphalographie gazeuse fractionnée (Fig. 9) : dilatation des citernes pré- et latéro-bulbaires, de la vallécule et des citernes des crêtes occipitales et péricalleuses.

Intervention opératoire et examen histologique : médulloblastome inséré sur le plancher du 4ème ventricule qui est complètement envahi par la tumeur, engagement amygdalien.

Cas 8. Petit garçon de 6 ans admis pour syndrome d'H. I. C.

Encéphalographie (Fig. 10) : absence d'insufflation du système *ventriculaire, dilatation* de la citerne ambiante gauche, compression de la citerne ambiante droite ; la citerne latéro-pontique droite est exclue alors que la gauche est insufflée.

Comptes rendus opératoire et histologique : médulloblastome du vermis cérébelleux envahissant la région de l'aqueduc de Sylvius.

Cas 9. Petit garçon de 3 ans admis pour syndrome d'H. I. C.

Encéphalographie (Fig. 11) : absence d'insufflation du système ventriculaire, *déformation* des citernes ambiantes, dilatation des ailes latérales.

Comptes rendus opératoire et histologique : médulloblastome du vermis cérébelleux envahissant la région de l'aqueduc de *Sylvius*.

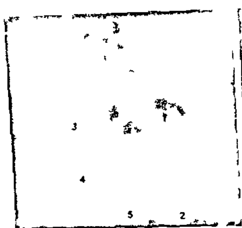


Fig 10 Dilatation de la citerne ambiante gauche (1) dilatation de la citerne ponto-cerebelleuse gauche (2) compression de la citerne ambiante droite (3) citerne crurale droite (4) et vallecule (5)



Fig 11 Deformation des citernes ambiantes (1) dilatation des ailes laterales (2) et dilatation des citernes de la crete occipitale (3)

Discussion

Ces signes traduisent une hydrocephalie externe localisee, consecutive au bouleversement de la dynamique du liquide cephalorachidien en pathologie tumorale De telles anomalies entrent dans le cadre des dilatations cisternales sus-tentorielles decrites par BULL ROTH et d autres, mais peuvent se rencontrer aussi bien dans les masses sus et sous-tentorielles Ces dilatations cisternales segmentaires asymetriques et non systematisees offrent une valeur diagnostique certaine dans les cas ou aucun indice pneumographique n oriente le diagnostic topographique sans toutefois permettre une localisation precise Certaines citernes mal visibles normalement deviennent apparentes telles que la citerne des cretes occipitales les ailes laterales des ambiantes la citerne sous-vermienne et les citernes pre et latero-bulbaires

A propos de la citerne des cretes occipitales des incidences de face avec rayon d inclinaison variable sont necessaires pour leur mise en evidence Il est rappele que toutes ces encephalographies à la recherche d une masse intra cranienne se pratiquent dans des conditions assez particulieres Il s agit dans un temps preoperatoire de localiser avec une quantite minimum d air sans soustraction liquidienne le processus expansif Il est inutile d injecter de trop fortes quantites de contraste gazeux pour mieux visualiser les formations cisternales dilatees, car celles-ci apparaissent en general des la premiere insufflation

L hydrocephalie externe passive entraine egalement des dilatations cisternales

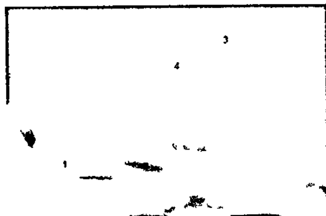


Fig 8 Grande citerne (1) citerne du velum interpositum dilatée (2) citerne susquadrigeminale deformée (3) et calcifications tumorales (4)



Fig 9 Vallécule dilatee (1) citernes latero- et prebulbaires dilatees (2) et citernes dilatees des cretes occipitales (3)

Examen encéphalographique (Figs 7 et 8) dilatation de la vallecule de la citerne de la crete occipitale droite et de la citerne ponto cérebelleuse gauche deformation et compression de la citerne gauche dilatation de la partie superieure de la citerne ambiante droite dilatation des ailes latérales des citernes ambiantes et péricalleuses et calcification tumorale

Comptes rendu operatoire et histologique médulloblastome du vermis avec extension vers l hemisphere cérébelleux droit

Cas 7 Petite fille de 6 ans admise pour cephalées fatigue troubles de la marche

A l examen on notait une hypotonie et une inclinaison de la tete vers le cote gauche nystagmus battant vers la gauche dans le regard lateral

Encéphalographie gazeuse fractionnée (Fig 9) dilatation des citernes pre et latero-bulbaire de la vallécule et des citernes des cretes occipitales et péricalleuse

Intervention operatoire et examen histologique medulloblastome insere sur le plancher du 4ème ventricule qui est completement envahi par la tumeur engagement amygdalien

Cas 8 Petit garçon de 6 ans admis pour syndrome d H I C

Encephalographie (Fig 10) absence d insufflation du systeme ventriculaire dilatation de la citerne ambiante gauche compression de la citerne ambiante droite la citerne latero-pontique droite est exclue alors que la gauche est insufflée

Comptes rendus opératoire et histologique medulloblastome du vermis cerébelleux envahissant la région de l aqueduc de Sylvius

Cas 9 Petit garçon de 3 ans admis pour syndrome d H I C

Encéphalographie (Fig 11) absence d insufflation du systeme ventriculaire deformation des citernes ambiantes dilatation des ailes latérales

Comptes rendus opératoire et histologique médulloblastome du vermis cerebelleux envahissant la région de l aqueduc de Sylvius

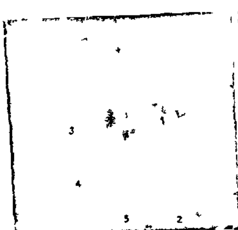


Fig 10 Dilatation de la citerne ambiante gauche (1) dilatation de la citerne ponto-cerebelleuse gauche (?) compression de la citerne ambiante droite (3) citerne crurale droite (4) et vallecule (5)

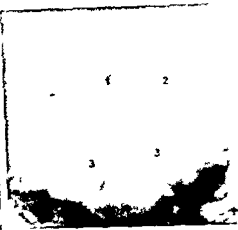


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L hydrocephalie externe passive entraine egalement des dilatations cisternales

mais celles ci sont globales et non deformees Parfois des injections cisternales partielles dues a une mauvaise technique pourraient preter a confusion

L'hydrocephalie externe active par contre, se caracterise par une dilatation cisternale segmentaire, asymetrique et non systematisee Ces anomalies cisternales semblent être l apanage surtout de l enfant, car dans la majeure partie de notre materiel, ces dilatations ont ete caracteristiques chez les tumeurs infantiles Il n est pas exclu que chez l enfant des phenomenes de collapsus cerebral interferent dans ces dilatations cisternales

RÉSUMÉ

Les auteurs decrivent des dilatations cisternales inedites telles que de la citerne des cretes occipitales de la vallécule et des ailes latérales des ambiantes Survenant dans des cas de processus expansif sus ou sous tentoriel entrainant une hydrocephalie externe active ces anomalies sont segmentaires asymétriques et non systématisées et ne peuvent en aucun cas apporter un diagnostic topographique precis mais sont d un appoint précieux en cas d obstruction du trou de Magendie et d absence d insufflation de la citerne de la grande veine de Galien

SUMMARY

Cisternal dilatations which seem to be fairly unknown such as dilatation of the cistern of the occipital crests of the vallecula and of the lateral wings of the ambient cistern are illustrated and discussed They are segmentary asymmetric and uncharacteristic and may *occur in cases of supra and subtentorial lesions leading to active external hydrocephalus* The anomalies are of no help in the establishment of an accurate topographical diagnosis but may be of importance in cases of occlusion of the foramen of Magendie and in non filling of the cistern of the great vein of Galen

ZUSAMMENFASSUNG

Dilatation der Cisternen die bisher relativ unbekannt zu sein scheint wie Dilatation der Cisterna Crista occipitalis der Vallecula und der lateralen Flugel der Cisterna ambiens wird illustriert und diskutiert Die Anomalien treten in supra und sub tentoriellen expandieren den Tumoren auf verursachen aktive externe Hydrocephalie sind unsymmetrisch und uncharakteristisch und kommen in lokal begrenzten Regionen vor Die Erscheinungen erbieten keine Hilfe zur exakten topographischen Diagnose konnen aber von Wert sein wenn das magendische Loch okkludiert ist und wenn die Cisterna der grossen galenischen Vene nicht dargestellt werden kann

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VENTRICULOGRAPHIE GAZEUSE DU IIIeme VENTRICULE DE L'AQUEDUC ET DU IVeme VENTRICULE

par

ALBERTO CALABRO

L encephalographie fractionnee est l examen de choix pour l etude radiographique de la fosse posterieure Cependant, quelquefois la ventriculographie est encore necessaire Avec la technique classique, la visualisation de la partie infratentorielle du systeme ventriculaire peut être dans certains cas difficile et insuffisante Pour cette raison, plusieurs methodes qui ont, en outre, l avantage d utiliser des quantites d air relativement petites ont ete proposees pour l etude selective de l aqueduc et du IVeme ventricule (ZIEDSES DES PLANTES, AZAMBUJA et coll , LAINE et coll), mais elles aussi ont parfois leurs difficultes et leurs echecs

C est pourquoi nous avons mis au point une technique facile a realiser et qui au cours de deux annees d experience, nous a toujours donne des resultats satisfaisants Nous procedons de la façon suivante

Le malade est allonge en procubitus sur la table du crâniographe, suffisamment en avant pour que la ligne mamillaire se trouve au niveau ou au dela du bord libre de la table, celle ci etant legerement ecartee du craniographe La ponction ventriculaire est faite 2 cm a droite ou a gauche de la ligne mediane, immediatement en avant de la suture coronale et l on ne fait pas sortir de liquide cephalo

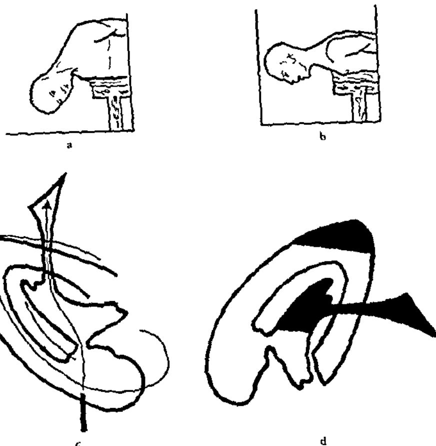


Fig 1 En (a) est représente la position de la tete au cours de la première et au debut de la deuxieme injection d air Le trajet de l air *est schématise en* (c) En (b) on observe la position de la tete a la fin de la deuxieme injection d *air et en* (d) la distribution du contraste (en noir) dans le système ventriculaire

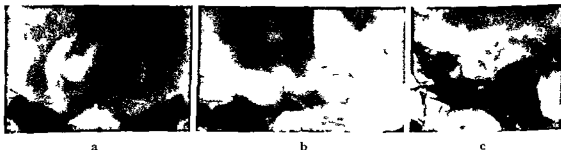
rachidien Sans faire bouger l aiguille la tete *et le cou* du malade sont alors fortement flechis afin que la ligne orbito-meatale resulte presque parallele au plan horizontal La tête est ensuite tournee de 50° a 60° environ vers le cote oppose a celui du ventricule ponctionne de sorte que ce dernier se trouve dans un plan inferieur et legerement posterieur par rapport au ventricule de l autre cote (Fig 1) A ce moment 15 ml de liquide *cephalorachidien* sont soustraits et une quantite analogue d air injectee en 15 secondes *environ* L air ainsi injecte se dirige dans sa montee a travers le trou de *Monro vers la* partie posterieure du IIIeme ventricule et passe de ce dernier dans l aqueduc et le IVeme *ventricule*



Fig 2 Aqueduc de Sylvius coude refoule en avant et vers la gauche ainsi que le quatrieme ventricule par un astrocytome du lobe cerebelleux droit

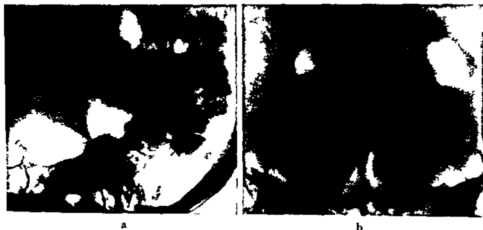
Dans le cas ou il n'existe pas de blocage, cet air passe plus ou moins vite dans l'espace sousarachnoidien cervical, et on pourra l'utiliser par la suite pour l'etude des citernes, comme dans une encephalographie fractionnee. Pour s'assurer donc d'une bonne visualisation ventriculaire, on pratique, apres soustraction d'une quantite analogue de liquide, une deuxieme injection de 10 a 15 ml d'air, plus rapide, 8 secondes environ, et en ayant soin de reduire, apres l'introduction des premiers 5 a 6 ml d'air, progressivement la flexion d'abord et la rotation ensuite de la tête et du cou de façon a ce qu'a la fin de l'injection la ligne orbitomeatale du crâne soit perpendiculaire au plan horizontal (Fig 1b)

Pendant ces manoeuvres, un peu de contraste passe, en general, dans la corne occipitale d'un seul ou des deux ventricules lateraux (Fig 1d), et ceci est utile parce qu'il permet d'etudier, si necessaire, la partie anterieure du IIIeme ven



a b c

Fig 3 Le quatrieme ventricule est dilate et en grande partie occupe par une masse venant de la gauche (a et b) La citerne prepontique n'est pas comprimee (c) A l'intervention il s'agissait d'un gros papillome



a b

Fig 4 Le quatrième ventricule qui est legèrement dilate redresse et refoule en ar riere (a) se trouve sur la ligne mediane et presente un defaut de remplissage dans sa paroi laterale gauche (b) L espace sous arachno dien en avant du tronc cerebral est comprimé (c) L etude de l espace sous arachnoidien cervical supérieur montre la limite inferieure de la tumeur (d) L autop sie confirma l existence d une tumeur du tronc etendue jusqu a la moelle cervicale superieure



c d

tricule et bien que de façon tres grossiere les ventricules lateraux Une fois l injec tion d air terminee sans remuer la tete on retire l aiguille on panse la blessure et en rapprochant la table au craniographe on place la tete bien droite sur la plaque de l appareil la ligne orbito-meatale etant toujours perpendiculaire a l horizontale On prend alors un cliche de profil avec rayon horizontal suivi d un deuxieme a tete legerement plus flechie et deux cliches de face avec rayon vertical respective ment perpendiculaire et incline de 20 environ en direction caudale (Fig 2)

Si l examen de ces cliches montre que l etude des citernes (Fig 3) et de l e pace sous arachnoidien cervical haut (Fig 4) est necessaire on continue l examen de la façon suivante

On baisse le plan du craniographe de 10 cm environ tout en flechissant la tete davantage de maniere a ce que celle-ci s appuie sur le bregma pendant dix secondes environ Ainsi l air quitte le IIIeme et le IVeme ventricule et se dirige dans la grande citerne et l espace sous archno dien cervical On tourne alors rapidement le malade en decubitus la region occipitale etant appuyee sur le plan du craniographe qui a ete entre temps souleve et incline de telle sorte que la

ligne orbito méatale forme un angle de 20° environ avec l'horizontale. Cett
position permet le passage de l'air dans les citernes en avant du tronc cérébral
dans les citernes suprasellaires et parfois dans la citerne de la lame *terminale* e
dans la partie antérieure de la *citerne du corps calleux*. On prend à ce momen
deux clichés de profil avec rayon horizontal, l'un pour l'étude de l'espace sous
arachnoïdien cervical haut, et l'autre pour l'étude des citernes, et éventuellemen
un cliché de face.

Enfin, s'il est *nécessaire*, une étude de la partie antérieure du troisième ven
tricule sera réalisée d'après la technique classique, en utilisant l'air présent dan
l'un ou les deux ventricules latéraux.

En conclusion, la facilité d'exécution, son innocuité — on n'a jamais observ
d'aggravation de l'état des malades à la suite de l'*examen dans nos* 50 *cas* — e
la constance des résultats nous ont incités à présenter cette méthode.

RÉSUMÉ

L'auteur décrit une technique de ventriculographie *gazeuse pour l'étude* de la parti
postérieure du IIIème ventricule, de l'aqueduc et du IVème *ventricule*, par laquelle il es
également possible, en l'absence de blocage ventriculaire, d'étudier l'espace sous arachnoïdien
Après ponction d'une corne frontale, le malade est placé en procubitus, la tête étant fléchi
et tournée de façon à ce que le ventricule ponctionné soit en bas. On injecte de 25 à 30 m
d'*air et soustrait* une quantité équivalente de liquide céphalorachidien de façon fractionnée
Vers la fin de l'injection on modifie la position de la tête, qui une fois l'introduction de l'ai
terminée, se trouvera placée de façon à ce que la ligne orbito méatale soit perpendiculaire a
sol. Cette technique bénigne s'est révélée utile dans certains cas de tumeurs et dans tous le
cas d'hydrocéphalie non tumorale de l'*enfance*.

SUMMARY

A method of gas ventriculography of the posterior portions of the 3rd ventricle, aqueduc
of Sylvius and the 4th ventricle, which in the absence of ventricular blockage also permit
a study of the subarachnoid space, is described. The anterior horn of a lateral ventricle i
punctured. Fractionated injection of 25 to 30 ml air and withdrawal of cerebrospinal flui
takes place with the patient prone and head so flexed that the punctured ventricle is directe
downward. The position of the head is successively changed towards the end of injection s
that finally the orbito meatal line becomes perpendicular to the floor. This technique ha
proved successful in cases of tumour and in all cases of hydrocephalus in children withou
tumour.

ZUSAMMENFASSUNG

Eine Technik für gasöse Ventrikulographie der hinteren Abschnitte des 3. Ventrikels de
Aquädukts und des 4. Ventrikels wird beschrieben. Wenn keine ventrikuläre Blockierung
vorliegt, ist es auch möglich die Subarachnoidalräume darzustellen. Das Vorderhorn des

Seitenventrikels wird punktiert Mit dem Patienten in Bauchlage und solcher Kopflage dass der punktierte Ventrikel nach unten liegt wird die Injektion von 25 bis 30 ml Luft unter fraktioniertem Austausch gegen eine aquivalente Menge der Cerebrospinalflussigkeit vorgenommen Die Kopflage wird gegen Ende der Injektion sukzessiv modifiziert und wenn die Injektion beendet ist soll die Augen Ohr Linie vertikal zur Horizontalen sein Die Methode hat sich in gewissen Fallen von Tumoren und im Kindesalter in allen Fallen von Hydrocephalus ohne Tumoren gut bewahrt

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF M SMOKVINA), UNIVERSITY HOSPITAL 'REBRO', ZAGREB, YUGOSLAVIA, AND THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR PROF J WELLAUER), UNIVERSITY OF ZURICH, SWITZERLAND

THE SOMERSAULT TECHNIQUE IN ENCEPHALOGRAPHY AND VENTRICULOGRAPHY

by

VLADIMIR GVOZDANOVIC

The employment of the somersault manoeuvre in ventriculography and encephalography was recommended by ZIEDSES DES PLANTES at the Second and the *Third Symposium Neuroradiologicum (Rotterdam 1949 and Stockholm 1952)* This technique was easy to apply in small children by manual somersaulting but was not possible in adults until 13 years later when the first somersault chair was described by GARCIA OLLER During the 3 year period that followed (1963—1965), three further developments of the somersault chair were reported by AMPLATZ, by POTTS & TAVERAS and by POTTS

The method, used widely by United States radiologists, has not been accepted to any extent in Europe This is unfortunate since the technique is simple Rotation of the patient forwards around the transverse axis moves the air from the trigone to the temporal horns Backward rotation outlines the posterior part of the third ventricle, the aqueduct and the fourth ventricle and demonstrates any changes

The author started to use the somersault technique in Zagreb in December 1965 and in Zurich in April 1967 Fig 1 depicts the chair Nine hundred somersaulting pneumographies (775 encephalographies and 125 ventriculographies) were performed, the material includes 674 encephalographies and 101 ventriculographies carried out in Zagreb from December 1965 to December 1967, as well as 111 encephalographies and 14 ventriculographies performed in Zurich in the middle of 1967

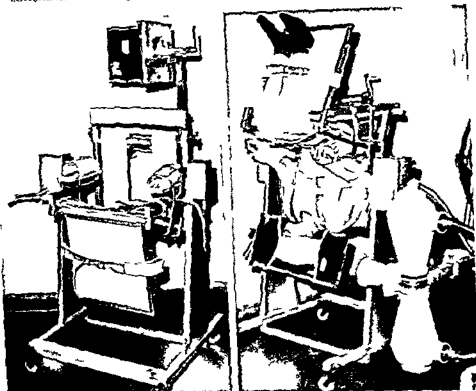


Fig 1 Somersault chair of home made design Fig 2 Patient in chair during rotation

The aim in the construction of the chair was to make it as simple and as in expensive as possible to allow every radiologist interested in neuroradiology to use the somersault technique It was surprising how well the somersault procedure was tolerated The patient is firmly attached to the chair (Fig 2) and with the aid of a simple device for head fixation autotomography may be performed in conscious as well as in anaesthetized patients The needle for the lumbar puncture may be left in situ this enables refilling or emptying of the ventricles or the subarachnoid spaces to be made at every step of the examination

The technique described by TAVERAS & WOOD is used The views of the temporal horns are obtained in lateral axial and half axial projections with the patient rotated forwards from the prone to the supine position Certain features in these projections described by LINDGREN are well known especially the knee and the supracornual cleft in the lateral view the lateral and supracornual clefts in the axial view and the bowl with the lateral cleft in the half axial



Fig 3 Slight dilatation of the left temporal horn of unknown origin (temporal epilepsy)



Fig 4 Flattening and medial displacement of left temporal horn, possible displacement of middle cerebral artery

view A comparison of these three views gives a spatial impression of the temporal horns

Simultaneous demonstration of both temporal horns in the same film is an advantage Minor pathologic changes producing small differences become evident on comparison of the two sides (Fig 3) The extent of more advanced changes may also be judged more easily by comparing both temporal horns Dilatation of the temporal horns of post traumatic, postoperative, postinflammatory, vascular or unknown origin were most often the subject of the present investigations The





Fig 5 Left temporal horn displaced cranially dilated flattened and shortened right horn dilated (Multiple arachnoid cysts)



Fig 6 Autotomogram during general anaesthesia Large tumour (pinealoma) in posterior part of third ventricle



Fig 7 Autotomogram during general anaesthesia Large tumour (medulloblastoma) growing from fourth ventricle into aqueduct

relation between the roentgen appearances of the initial dilatation of the temporal horns and the clinical and laboratory findings is at present being explored Space occupying temporal processes are more often investigated by angiography but it may happen that small changes are better shown by comparing the positions of the temporal horns (Fig 4) Changes produced by multiple expanding factors were demonstrated in one patient (Fig 5)

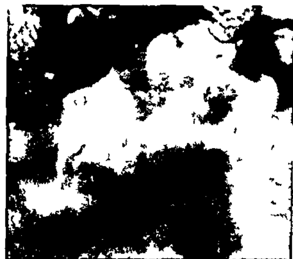
Apart from the usual premedication psychologic preparation of the conscious patient is of great value In a friendly chat the patient is informed exactly about the whole procedure (if possible by own physician) before being taken to the roentgen department He is told that he will be attached to a special chair and somersaulted like an astronaut that the whole procedure is safe and he cannot get hurt and that the technique in question is of great importance for an exact diagnosis of his illness With patients prepared in this manner no troubles have arisen

The pathologic changes of the third ventricle aqueduct and fourth ventricle which are usually difficult to demonstrate by ventriculography with the common technique are well shown by rotating the patient backwards from supine to prone position (Figs 6 and 7)



a

Fig 8 Emptying and refilling of the ventricular system before rotation (a) in vertex down position (b) and autotomogram in the sitting position (c)



b



c

In patients with a free passage of the spinal fluid it is possible to empty the air from the ventricles into the spinal subarachnoid space by backward rotation The air returns to the fourth ventricle, aqueduct, and third ventricle as well as to the subarachnoid spaces at the convexity and base of the brain when the sitting position is resumed (Fig 8)

The amount of air used may be considerably reduced when the somersault technique is employed in ventriculography (Fig 9)

Films may be made in each phase of the rotation, e g in the vertex down position, which is known to be particularly useful for the demonstration of tumours of the third ventricle and suprasellar region Autotomography in this



Fig 9 Displacement of the aqueduct and the fourth ventricle demonstrated at ventriculography with 10 ml of air Medulloblastoma of vermis infiltrating the left hemisphere

position in cooperative patients has been found to improve considerably *the possibility* of demonstrating the structures of the suprasellar region

There have been no accidents or fatalities so far in connection with the use of the *somersault technique*

Conclusion

Somersault pneumography *is an* easy and useful procedure and one that facilitates the simultaneous demonstration of both temporal horns The technique is of particular value in ventriculography It makes the whole procedure easier safer and more rapid furthermore *it* is diagnostically more informative as the details of the posterior fossa *may also* be demonstrated with small amounts of air It appears to us that *the somersault* technique *is superior* to ventriculography *with* iodized oil and that ventriculography *without* somersaulting is incomplete if the posterior fossa structures are to be investigated

In all the somersault technique *appears to* be the one of choice for a complete investigation of the ventricular and subarachnoidal *systems*

Acknowledgements

The author takes this opportunity of thanking Prof J Wellauer for his kind invitation to work in Zurich He is also grateful to S Grobenski who made the chair

SUMMARY

Seven hundred and seventy five encephalographies and 125 ventriculographies have been performed by the somersault technique with the aid of a simple home made chair The method is most useful for the simultaneous demonstration of both the temporal horns and in ventriculography for demonstrating the posterior part of the third ventricle the aqueduct and the fourth ventricle The amount of air employed may be reduced No accidents or fatalities have been encountered so far

ZUSAMMENFASSUNG

Siebenhundert funf und siebzig Enzephalographien und hundert funf und zwanzig Ventrikulographien wurden mit Hilfe eines einfachen selbst fabrizierten Kippstuhles vorgenommen Die Methode hat den Vorteil dass beide Temporalhorner gleichzeitig dargestellt werden konnen Bei Ventrikulographie konnen die Hinterwand des dritten Ventrikels der Aquadukt und der vierte Ventrikel gut dargestellt werden Man kommt bei dieser Methode mit kleineren Luftmengen aus Bis jetzt waren keine Komplikationen oder Todesfalle vorhanden

RÉSUMÉ

Sept cent soixante quinze encéphalographies et 125 ventriculographies ont été faites avec la technique du « saut périlleux » au moyen d un simple fauteuil de confection artisanale Cette methode est d une tres grande utilite pour montrer simultanement les deux cornes temporales et en ventriculographie pour mettre en evidence la partie postérieure du troisieme ventricule l aqueduc et le quatrieme ventricule On peut reduire la quantité d air injecté L auteur n a eu jusqu a maintenant ni accident ni decès

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DISPLACEMENT OF THE AQUEDUCT OF SYLVIUS BY POSTERIOR FOSSA TUMORS

Experimental and clinical studies

by

S K Hilal H Tookoian and E H Wood

The mechanisms of displacement of the brain stem due to tumors of the posterior fossa were studied both experimentally in cadavers where artificial masses were produced and on encephalograms obtained clinically The clinical cases were confirmed either by surgery or at autopsy The purpose of this work is to establish additional criteria that can be used to more accurately evaluate the size and location of the various tumors in the posterior fossa The report will be limited to tumors of the posterior compartment of the posterior fossa

Material and Methods

A *Production of experimental masses in human cadavers*

The material consisted of cases in which death due to disease not affecting the brain had occurred recently

The technique consists essentially in obtaining a positive contrast ventriculogram of the third ventricle and the aqueduct of Sylvius and producing a radiographically visible mass of known size and location in the posterior fossa The entire procedure progresses under fluoroscopic control


Fig 1


Fig 2

Fig 1 Anterior horns of lateral ventricles outlined by air Third ventricle aqueduct and fourth ventricle outlined by positive contrast medium some of the mixture is seen escaping through foramen of Monro into lateral ventricle and collecting in the occipital horn Ventriculographic needle in place

Fig 2 An artificial mass produced post mortem is present in the cerebellum below the level of the fastigium (arrows) The needle used for the injection of the wax mass is in place

The scalp is incised, the calvarium exposed and, using an electric drill, a 3 mm hole is made in the mid sagittal line at a point about 9 cm above the lambda. A needle is introduced through the drill hole so that its point is directed towards the sella turcica The position and direction of the needle are checked in both antero-posterior and lateral projections with a portable image intensifier mounted on a C arm The needle is maintained strictly in the midline and is advanced through the corpus callosum towards the sella until its tip is about 2 cm from the level of the diaphragma sellae At this location the needle point is in the third ventricle and air is injected under fluoroscopic observation The anterior part of the third ventricle and the frontal horns of the lateral ventricles are usually outlined (Fig 1) The needle is prevented from advancing further by using a small protective guard which can be fixed on its stem After localization with air, a barium suspension is introduced into the third ventricle through the needle (The suspension contains 80 g of micro-barium suspended in 500 ml of the commercial product Pepto-Bismol chosen as a suspending medium because of its good coating characteristic) After satisfactory contrast filling of the third ventricle and the aqueduct two polaroid roentgenograms of the skull are obtained one in postero anterior projection, and one in lateral projection

Experimental masses are then produced by injecting contrast material into the

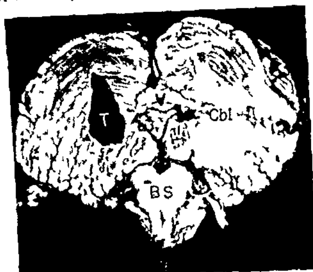


Fig 3 Section through the brain stem (B S) the cerebellar hemisphere (Cbl) and vermis (V) showing the experimental tumor (T)

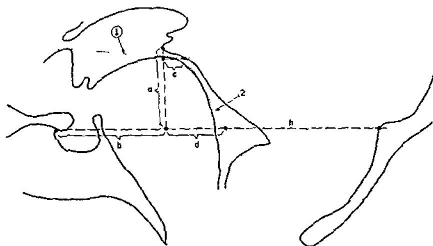


Fig 4 Diagram of the measurements of the aqueduct and the posterior commissure The vertical reference line *a* and the horizontal reference line *b* are shown along with lines 1 and 2 which are the two tangents on the floor of the aqueduct at its rostral and caudal ends The distances *c* and *d* are explained in the text



Fig. 5. Tracings of the 92 cases of posterior fossa tumors included in the material. The dotted lines are the horizontal reference lines.

posterior fossa through a second drill hole made in the occipital bone below the level of the tentorium. A 3 inch long needle is introduced through this second hole and is directed under fluoroscopy to any pre-selected part of the posterior fossa (Fig. 2). The material used to produce these artificial masses is a mixture containing 100 g solid floor wax, 50 ml Pantopaque (30 % iodine) and 20 g paraffin wax. The components are heated to the melting point of the wax to assure homogenous mixing. The liquid mixture is then loaded in syringes. Upon cooling, this mixture has the consistency of soft cheese and can be easily injected (pre-warming the syringe in running hot water immediately before usage facilitates the injection).

When a mass of predetermined size has been produced at the desired location of the posterior fossa, two polaroid roentgenograms of the skull are obtained, one in postero-anterior projection and one in lateral projection. The size of the mass is then increased by a given amount and two more polaroid roentgenograms

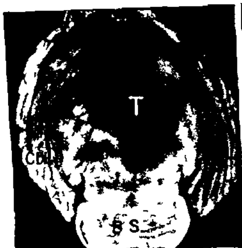


Fig 6 Horizontal section through the brain stem (B S) and cerebellum (Cbl) in a case of intraventricular medulloblastoma The tumor (T) fills the entire fourth ventricle and causes brain stem compression

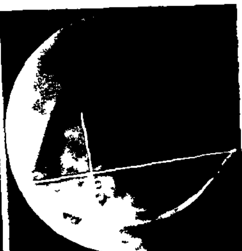


Fig 7 Pneumogram showing a midline cerebellar tumor (medulloblastoma) presenting chiefly in the fourth ventricle and producing anterior displacement of the floor of the aqueduct forward of the vertical reference line

are produced The process is repeated until the mass reaches a volume of 35 to 40 ml (In the present studies a pair of films were exposed as the mass attained 2 5 5 10, 20 25, 30 and 35 ml in size positioning of the head for the roentgenograms was ascertained by fluoroscopic control superimposition of the auditory canals and the orbital roofs were the criteria used for the lateral projection while in the postero-anterior views special attention was paid to preventing any lateral rotation of the skull)

At the end of the procedure the brain is removed and fixed for two weeks The brain stem and cerebellum are kept attached and are sectioned transversely in a plane perpendicular to the axis of the brain stem The location and extent of the artificial masses are thus determined and photographs of the various sections are obtained (Fig 3)

B *Radiographic measurements in clinical material*

Measurements were made on the encephalograms obtained clinically in patients suffering from tumors of the posterior fossa (Fig 4) The measurements are based on two reference lines one horizontal and one vertical The horizontal reference is Twining s line which extends from the tuberculum sellae to the internal occipital protuberance The vertical reference is a perpendicular dropped from

Table

Type of kink of aqueduct	Lateral shift of aqueduct	Tumor location
Adital kink	No	Vermis and intraventricular
Adital kink	Yes	Cerebellar hemisphere masses crossing the midline
Midaqueductal kink	No	Vermis and intraventricular masses infiltrating the brain stem
Midaqueductal kink	Yes	Cerebellar hemisphere masses not crossing the midline
Midaqueductal kink	Yes (mostly IV ventricle displacement)	Small low lying cerebellar hemisphere masses usually cystic
Midaqueductal kink or no kink	Yes	Masses of the cerebellum extending anteriorly

the rostral border of the posterior commissure to Twining s line The relation ship of the brain stem to these two reference lines is established by drawing two tangents to the floor of the aqueduct, one at its rostral end and the other at its caudal end (Fig 4) The distance from the point of intersection of the caudal tangent and Twining s line to the point of intersection of the two reference lines was called *d* The distance from the point of intersection of the two tangents to the vertical reference line was called *c* The distance *d* is related to the position of the lower part of the mid brain, while distance *c* is related to the position of the upper part of the mid brain

The pneumograms of 92 patients with tumor of the posterior fossa were traced and measured using the methods described above (Fig 5) Seventy one of the patients had tumors arising in the cerebellar substance as may be seen from the Table The other 21 were tumors of extra axial origin infiltrating the cerebellum, mostly arising from the cerebellopontine angle

Results

A *Normal measurements*

The relative location of the posterior commissure was determined by measuring the length of the vertical reference line (distance *a*) and by measuring the

Table (cont)

Number of patients	Measurement c		Measurement d		Remarks
	Range mm	Average mm	Range mm	Average mm	
10	0—?	0 9	0—4	1 3	No exceptions
20	1—? 5	1 5	5—8	1 5	Two exceptions two pat ents had a larg cerebellar hemispheric mass that did not infiltrate the vermis
7	3—4	3 5	2—7	4 8	No exceptions
15	3—4	3 1	0—7	5 4	No except ons
7	?—6	3 5	8—9	8 2	These tumors produced a min mal de crease of *d* because of their small size or low position or both
12	4—9	6 5	10—19	14 9	No except ons these masses arose from the cerebellar hem sphere and extended to the brain stem or C P angle

distance between the tuberculum sellae and the point of intersection of the two reference lines (distance b) The values in twenty normal adult patients were $a = 24.3$ *mm* (standard deviation ± 3 2) $b = 26.1$ mm (standard deviation ± 5 1)

In infants and young children the posterior commissure was found to be normally higher and more anteriorly located than in adults resulting in large values for a and small values for b

In our series of adult patients with cerebellar tumors the measurements (a and b) which determine the location of the posterior commissure within the bony skull showed no statistically significant change from the normal values Because cerebellar masses do not appreciably affect the location of the posterior commissure the vertical reference line can be considered a relatively constant landmark Consequently the measurements (c and d) which relate the brain stem to this vertical reference line become reliable indicators of displacement of the brain stem in the anteroposterior direction

The normal values for measurements c and d were found to be $c = 5.6$ mm (standard deviation ± 1 6) $d = 12.7$ mm (standard deviation ± 1 9)

Anterior displacement of the brain stem results in a decrease of the distance c or d or both



Fig 8 Diagram indicating the method of rotation of the brain stem in the sagittal plane due to tumor of the cerebellum The center of this rotation is around a point near the aditus of the aqueduct

B *Mechanisms of anterior displacement of floor of aqueduct*

From the cadaver study and from the review of the specimens obtained at autopsy on the patients with posterior fossa tumors it is possible to describe three factors that contribute to the anterior displacement of the floor of the aqueduct These factors are described below

1 *Compression of the antero posterior diameter of the brain stem* was demonstrated in the pathologic specimens of the brain stem and cerebellum obtained at autopsy (Fig 6) Such brain stem deformity was most prominent in patients suffering from midline tumors growing into the fourth ventricle, and was least marked in cases of cerebellar hemisphere tumors

Radiographically, the brain stem compression appears on the lateral view as a uniform forward displacement of the floor of the aqueduct and the fourth ventricle resulting in a decrease of both measurements *c* and *d* In such cases the floor of the aqueduct throughout its entire length moves forward closer to the vertical reference line (Fig 7) This deformity of the aqueduct was called the 'adital kink' since the displacement seemed to start at the aditus of the aqueduct at the outlet of the third ventricle It should be noted that this term refers *only* to the appearance of the floor of the aqueduct The quadrigeminal plate can be *independently displaced posteriorly or kinked at the intercollicular* level as described by LINDGREN & DI CHIRO (1953)

2 *Rotation of the brain stem in the sagittal plane* Tumors of the posterior compartment of the posterior fossa will cause the brain stem to rotate forward and upward *around a point located in the floor of the aditus of the aqueduct* (Fig 8) This motion of the brain stem in the sagittal plane will result in an



Fig 9 Parts of three polaroid roentgenograms obtained in conjunction with an experimental mass produced in the vermis The vertical white line is the vertical reference line the dotted lines are the horizontal reference lines The mass (arrows) is shown from top to bottom, at sizes of 2 5 10 and 35 cm³ respectively Forward displacement of the aqueduct and upward displacement of the floor of the third ventricle occurs

terior displacement of the floor of the aqueduct and the fourth ventricle The caudal elements however will tend to move more than the rostral end since the center of rotation is near the aditus of the aqueduct

Associated with the anterior displacement of the brain stem there is closure of the pontine cistern and elevation of the floor of the third ventricle The development of these changes can be demonstrated on serial polaroid roentgenograms obtained with a midline experimental mass (Fig 9) As the mass increases in size the aqueduct is seen to move forward while the floor of the third ventricle moves upward closer to the tip of the stabilized needle used for ventriculography

With sagittal rotation of the brain stem resulting in more displacement of the caudal end of the aqueduct both measurements *c* and *d* are decreased with *d* showing the more significant reduction Simple flattening of the brain stem on the other hand results in anterior displacement at both ends of the aqueduct without the preferential decrease in *d*

3 *Segmental axial rotation of the brain stem* Tumors of a cerebellar hemisphere displace the dorsal aspect of the brain stem to the contralateral side, while the ventral aspect of the brain stem anchored by nerves and vessels shows minimal lateral displacement Because of its relative fixation anteriorly the brain stem thus rotates away from the tumor rather than simply moving laterally The axis of rotation is parallel to the clivus and lies near the anterior surface of the brain stem This rotation of the brain stem is illustrated in the cross-sectional diagram of Fig 10 Such rotation is also observed in the pathological specimens

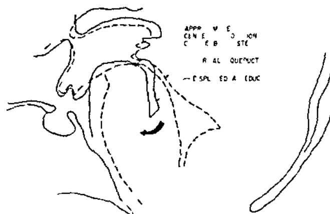


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Fig 11 Autopsy specimen showing segmental axial rotation The brain stem (B S) is rotated by a cerebellar (Cbl) hemispheric tumor (T) The a p diameter of the brain stem is not decreased by flattening

ferentiation is based on the appearance of the floor of the aqueduct and its relation to the posterior commissure and the vertical reference line, regardless of the shape and orientation of the quadrigeminal plate

In an adital kink the floor of the aqueduct is displaced forward throughout its entire length toward the vertical reference line As the floor of the third ventricle is traced caudally it appears to suddenly change direction at the aditus of the aqueduct taking a course close to the vertical reference line (Fig 13)

In the case of a midaqueductal kink on the other hand the caudal end of the aqueduct is more anteriorly displaced than its rostral end As the floor of the third ventricle is followed caudally into the aqueduct it extends first posteriorly behind the vertical reference line for a short distance and then changes its direction to a forward and downward course The change in direction occurs at a point located approximately at the midaqueductal level In most cases the type of kink can be determined by simple observation and at other times measurements may be useful to substantiate the changes

The aqueduct is considered displaced forward when measurement *d* is 7 mm or less this is more than two standard deviations below the average normal value A measurement of 8 to 9 mm represents a borderline situation this occurs in a small group of cerebellar tumors (group 5 in the table) which were usually cystic small and placed in the most caudal portion of the posterior fossa. Measurements of distance *d* between 9 and 15 mm were considered normal

The differentiation between a midaqueductal kink and an adital kink is strongly dependent on measurement *c* A value of 3 mm or more is associated with a midaqueductal kink it means that the rostral end of the midbrain is not

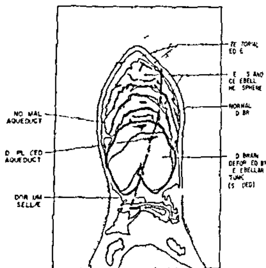


Fig 10 Diagram of a horizontal section of the rostal end of the posterior fossa The normal appearance of the brain stem and cerebellum is shown and superimposed upon it is the outline of a corresponding section of the brain stem from a case of a cerebellar hemisphere tumor as obtained at autopsy (dashed area) The heavy dotted line passes through the distorted interpeduncular fossa aqueduct and vermis of the pathologic tumor case illustrating the displacement of the midline structures

obtained from patients with cerebellar hemispheric tumors (Fig 11) The mid brain, which is not appreciably compressed in its anteroposterior dimension by *hemispheric tumors, is seen to be rotated contralaterally bringing the aqueduct* beyond the midline and anteriorly Again, the rotation affects the lower segment of the mid brain, which is nearer to the tumor, more than the rostral end which is supratentorial Consequently the caudal part of the aqueduct will be more *anteriorly displaced than the rostral part, resulting in the appearance* of a kink, which in the lateral view starts in the middle of the aqueduct (Fig 14) The mechanism is illustrated in the three dimensional drawing shown in Fig 12 Roentgenograms of this type of aqueductal kink show a marked decrease of measurement *d* while measurement *c* is just below the normal value

It is evident from the above that the rostral end of the brain stem lends itself the least to anterior displacement Such displacement, when it occurs, is usually due to high masses, as in the case of tumors of the superior vermis Obstructing tumors in the fourth ventricle causing dilatation of the aqueduct have a similar effect because the dilated fourth ventricle itself acts as a mass extending rostrally and dorsally

C *Measurements of the aqueduct in patients with cerebellar tumors*

The clinical material used for this analysis is summarized in the Table The cases are grouped according to the appearance of the aqueduct in lateral and postero anterior projections In the lateral view, the kinked appearance of the anteriorly displaced aqueduct was classified as midaqueductal or adital The dif



Fig 13 Adital kink of aqueduct in case of cerebellar hemispheric tumor infiltrating vermis Floor of aqueduct close to vertical reference line



Fig 14 Midaqueductal kink due to an astrocytoma of the cerebellar hemisphere not infiltrating the vermis

the cadaver study it was possible to determine that the rostral end of the mid brain is the segment of the brain stem that lends itself the least to anterior displacement by cerebellar masses This concept is the basis for the separation of the two types of aqueductal kinks described above

B *Advantages of the proposed measurements* Many measurements of the aqueduct of Sylvius (DAVIDOFF & DYKE 1937, SUTTON 1950) and of the fourth ventricle (MCRAE & ELLIOTT 1958 TWINING 1939) have been described by other authors The measurement technique discussed in this presentation differs from previous work in two respects First, it provides a vertical reference line which because of its proximity to the aqueduct permits a more accurate detection of displacement Second with the use of two tangents on the posterior aspect of the brain stem the proposed method provides a way to separately evaluate the displacement of the rostral and caudal ends of the midbrain

C *Interpretation of aqueductal measurements obtained in patients with cerebellar tumors and their practical applications* From the data presented in the table it is seen that adital kinks of the aqueduct are associated with the masses directly behind the brain stem i e upper vermis masses cerebellar masses infiltrating the vermis and masses of the fourth ventricle The midaqueductal kinks are observed with tumors of the cerebellar hemispheres that have not infiltrated the vermis and with midline posterior tumors which have extended anteriorly to involve the brain stem or the region of the cerebello-pontine angle

Based on these observations, it becomes possible to determine if a cerebellar

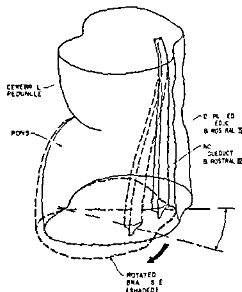


Fig 12 A three dimensional diagram of the cerebral peduncles and pons The effect of segmental axial rotation of the brain stem on the appearance of the aqueduct is illustrated The lower part of the pons is rotated around a point near its anterior surface where the two dotted lines meet The lower part of the aqueduct is displaced forward and laterally as a result of this axial rotation of a segment of the brain stem

significantly displaced forward When value *c* is less than 3 mm, the kink is of the adital type The cases showing each of these two types of kinks have been subdivided in the table according to the presence or absence of a lateral shift of the aqueduct

The last group represents patients with cerebellar masses extending anteriorly into the brain stem or the cerebellopontine angle Radiographically, these patients exhibited a midaqueductal kink without anterior displacement of the caudal aqueduct (measurement *d* was either normal or larger than the normal range) The midaqueductal kink is due to the segmental axial rotation An example of such a pneumogram is shown in Fig 15, along with the autopsy specimen of the same case, demonstrating rotation of the brain stem It should be noted that the anteroposterior dimension of the pons is not reduced although the bulk of the tumor is in the cerebellar hemisphere

Discussion

A *Merits and limitations of the cadaver study* The artificial masses differ from pathologic tumors in many respects There is no hydrocephalus resulting from these wax masses and there is no brain atrophy associated with them These experiments have, however, provided an excellent opportunity to study the effect of the anterior fixation of the brain stem and the effect of the geometry of the posterior fossa on the displacements of the various structures With the help of

SUMMARY

A technique for production of artificial radiographically demonstrable lesions in cadavers is presented it is used to analyse brain stem displacements associated with posterior fossa masses Three processes of anterior displacement of the aqueductal floor are described brain stem compression, forward rotation of the brain stem in the sagittal plane and segmental axial rotation of the brain stem Usually only lesions immediately behind the brain stem cause anterior displacement of its rostral end Two types of anterior kinks of the aqueduct the adital and the midaqueductal depending on the position of the upper part of the brain stem are described Such observations will permit a more accurate evaluation of the origin and extent of tumors in the posterior part of the posterior fossa

ZUSAMMENFASSUNG

Eine Technik zum Hervorrufen von artifiziellen radiographisch nachweisbaren Lasionen in Kadavern wird beschrieben die Methode kommt fur die Analyse der Gehirnstammverschiebungen zur Anwendung die in Verbindung mit Lasionen der hinteren Schadelgrube vorkommen Drei Vorgange bei der Verschiebung nach vorn vom Aquaduktboden werden beschrieben Kompression vom Gehirnstamm Rotation des Gehirnstammes vorwarts in die Sagittalebene und eine segmentare Axialrotation des Gehirnstammes Verschiebungen nach vorn werden gewohnlicherweise nur von Lasionen unmittelbar hinter dem Gehirnstamm verursacht Zwei Typen von Vorwartsknickung des Aquadukts die aditale und die mediale die von der Lage des oberen Teiles des Gehirnstammes abhangig sind werden beschrieben Mit Berucksichtigung derartiger Untersuchungsbefunde wird es moglich den Ursprung und die Ausbreitung von Tumoren im hinteren Teil der hinteren Schadelgrube mit grosserer Genauigkeit fastzustellen

RÉSUMÉ

Les auteurs presentent une technique permettant de creer des tumeurs artificielles radiovisibles dans des cadavres utilisée pour etudier les deplacements du tronc cérébral dus aux tumeurs de la fosse postérieure Ils decrivent 3 causes de déplacement du plancher de l'aqueduc vers l'avant la compression du tronc cérébral la rotation en avant du tronc cérébral dans le plan sagittal et la rotation axiale segmentaire du tronc cerébral Habituellement seules les lesions situees immediatement derriere le tronc cerebral peuvent causer un deplacement vers l'avant Les auteurs d crivent deux types de coudure anterieure de l'aqueduc suivant la position de la partie superieure du tronc cerebral a savoir la partie initiale et la partie moyenne de l'aqueduc L'utilisation de ces resultats permet de determiner plus exactement l'origine et l'extension des tumeurs de la partie posterieure de la fosse postérieure

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Fig 15 Forward infiltration of a cerebellar tumor a) The tumor extended forward into the cerebellopontine angle which caused kinking of the aqueduct but prevented its anterior displacement the tumor also caused segmental axial rotation of the brain stem which resulted in the midaqueductal kink b) Autopsy specimen confirming the anterior infiltration of the tumor (arrows) and the axial rotation of the brain stem (the brain stem is not compressed in its anteroposterior diameter)

hemisphere mass has crossed the midline, or, if a posterior midline mass has infiltrated forward In the first instance, the aqueduct is laterally shifted and is usually kinked at the aditus, while in the latter case a midaqueductal kink is usually seen in the absence of a lateral shift The ability to accurately determine the location and extent of cerebellar tumors constitutes a primary practical application of this work

A kinked aqueduct without anterior displacement (Fig 15) is due to a cerebellar hemisphere tumor that has infiltrated forward Tumors of the cerebellopontine angle infiltrating the cerebellum will produce the same deformity of the aqueduct and fourth ventricle It is sometimes impossible to separate these two conditions on the basis of the appearance of the aqueduct and the fourth ventricle alone

Acknowledgement

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ROM THE DEPARTMENT OF NEUROSURGERY, OKAYAMA UNIVERSITY, OKAYAMA CITY
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SPATIAL INTERRELATIONSHIP BETWEEN CRANIOCEREBRAL REFERENCE POINTS AND BASAL GANGLIA

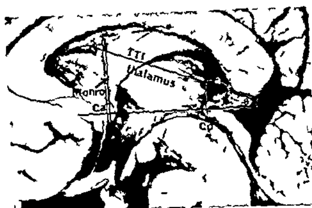
by

T KATOW A NISHIMOTO K MATSUMOTO, A SUZUKI and T OHMOTO

No definite rule or method appears to have been established in the selection of various intracerebral and cranial reference points in the cubic representation of target points for stereotaxic surgery This has caused much inconvenience in endeavours to appreciate and compare results obtained with the various methods of stereotaximetry Racial differences in the spatial interrelationships of the reference points and the basal ganglia have recently been noted It may therefore be of interest to present the results of an investigation of these differences in a series of encephalographies and ventriculographies carried out in 130 patients and in 15 cadavers of Japanese origin

The measurements were taken from the cranial reference points of the anthropologic basal line and auricular line and the intracerebral reference points of the anterior commissure (Ca) posterior commissure (Cp) midpoint of the Ca—Cp line (Mp) and the foramen of Monro (FM) The procedure of fixation and measurement of the brain was the same as employed by MATSUMOTO (1961) The anthropologic basal line and the Ca—Cp line cross posteriorly at an average of 8 degrees and 64 6 % of all the 130 cases investigated are included in the ±3 7 degree of standard deviation

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The mid sagittal plane total thalamic length (TTL) commissura anterior (Ca) commissura posterior (Cp) and foramen of Monro

The purpose of investigating the relations between the cranial and intracerebral reference points was primarily to estimate the value of determining the position of the intracerebral reference points when it had been found difficult satisfactorily to demonstrate the ventricular system It was however found that such relationships were unreliable because of the considerable variations in position The measurements of the distances to the basal ganglia, such as the globus pallidus the anterior lateral ventral centromedian and dorsomedial nuclei of the thalamus the corpus Luysi the nucleus ruber, the Forel H field and the substantia nigra were taken from the reference points of FM, Ca Mp and Cp and the variations in the average distances of the midpoints or the anterior and posterior borders of the basal ganglia from these points were calculated The standard deviations are given in Table 1

Considering the red nucleus for example which is located relatively posteriorly in comparison with the standard reference points the deviation with reference to Cp was less in a sagittal direction (0 7 mm) while the deviation in relation to Ca was greater (1 6 mm) The caudate nucleus which is more anterior to the reference points deviated less with reference to FM (1 0 mm) and more with reference to Cp (2 5 mm) The Forel H field which is approximately in the middle of the Ca—Cp line showed a minimal deviation with reference to Mp and greater deviations in relation to Ca and Cp

In view of these facts and as suggested by VAN BUREN & MACCUBBIN (1962), it may be pointed out that for the selection of standard reference points in stereotaximetry to be correct these should lie as close to the target point as possible

Table 1

Results of measurement of distances of the basal ganglia in sagittal direction from different reference points (standard deviations in mm)

Structures	Reference points			
	Foramen of Monro	Commissura anterior (Ca)	Midpoint between Ca and Cp	Commissura posterior (Cp)
Midpoint of nucleus ruber	1.4	1.6	0.8	0.7
Midpoint of corpus Luysi	1.1	1.0	0.6	1.3
Midpoint of globus pallidus	1.3	1.4	1.3	1.8
Midpoint of nucleus anterior thalami	0.8	1.1	0.8	1.5
Midpoint of centrum medianum thalami	1.5	1.8	1.0	0.5
Midpoint of Forel H field	1.0	1.2	0.5	1.1
Ant. border of putamen	1.3	1.4	2.0	2.4
Post. border of putamen	2.0	2.2	1.7	1.4
Ant. border of nucleus caudatus	1.0	1.0	2.3	2.5

Table 2

Variations in the total length of the thalamus in relation to the posterior commissure

Case	TTL (mm)	a (mm)	$\frac{a}{TTL} \times 100$ (%)	θ (degree)
1	33	7	21.2	6
2	35	7	20.0	6
3	38	7	18.4	11
4	36	6	16.6	7
5	38	8	21.0	7
6	40	9	22.5	10
7	35	7	20.0	10
8	40	9	22.5	11
Range	33~40	6~9	16.6~22.5	6~11
Average	36.8	7.5	20.3	8.5

TTL Total length of thalamus
a Distance from the posterior commissure to the tip of pulvinar
θ Angle of the antero posterior axis of thalamus to the Ca Cp line

FROM THE NEURORADIOLOGICAL AND NEUROPATHOLOGICAL DEPARTMENTS OF THE PSYCHONEUROLOGICAL INSTITUTE (DIRECTOR PROF Z W KULIGOWSKI), WARSZAWA PRUSZKOW POLAND

DEFORMATION OF THE LATERAL VENTRICLES OF THE BRAIN DUE TO EPENDYMAL FUSIONS

by

PIOTR KOZLOWSKI and JERZY DYMECKI

Unusually small lateral ventricles of the brain without displacement, is not an uncommon finding on routine encephalography, the pathogenesis is not always clear however Sixty consecutive post mortem encephalographies, as well as gross and microscopic examinations of the brains were performed in an attempt to explain these appearances

Seven cases had small lateral ventricles at encephalography in five of these one (Fig 1) and in two of them both (Fig 2) lateral ventricles were small Shortening of the upper and lateral wall of the ventricles as well as increased sharpness of the external angle were also sometimes seen Three types of ependymal changes in the regions of fusions were recorded at microscopy The first type was represented by continuous fusion of the upper and lateral ventricular walls to form a double row of adjoining ependymal cells (Fig 3a) The second type consisted in fusion of parts of walls to form separate oval or cleft like parts of the ventricle not communicating with the lumen The adhesion of the subependymal glia of both ventricle walls between the separated parts of the ventricle was observed (Fig 3b) The third type was represented by irregular

Since the thalamus has so far been the most common target in stereotaxic surgery, we made further measurements of the antero-posterior axis and the total length of the thalamus in an additional number of eight human brains, as illustrated in the accompanying figure The results of these measurements are given in Table 2 and indicate that the distance between the posterior border of the thalamus and the reference point Cp is smaller in a sagittal direction and varies in the range of 16 6 % to 22 5 % of the total length of the thalamus, i e is less in Japanese subjects in comparison with Western subjects according to the values reported by BRIERLEY & BECK (1959) which were in the range 26 % to 41 %

SUMMARY

Measurements were performed to investigate the relations between the intracerebral and cranial reference points in stereotaximetry but no reliable relationship could be established The study revealed that a marked difference exists in the size of the thalamus between Japanese and Western subjects

ZUSAMMENFASSUNG

Messungen wurden vorgenommen, um die Relationen zwischen den intracerebralen und kranialen Referenzpunkten der Stereotaximetrie zu untersuchen und die Resultate deuteten darauf hin dass keine zuverlässige Beziehung besteht Ein markanter Unterschied in der Grosse des Thalamus bei Japanern im Vergleich mit Europaern wurde festgestellt

RÉSUMÉ

Les auteurs ont cherché s il existe des rapports utilisables en stéréotaximétrie entre des points de référence intracraniens et des points extracraniens ils n ont pas trouvé de rapports constants Leur étude a pourtant montré qu il y a une différence marquée entre les dimensions du thalamus chez les Japonais et chez les Occidentaux

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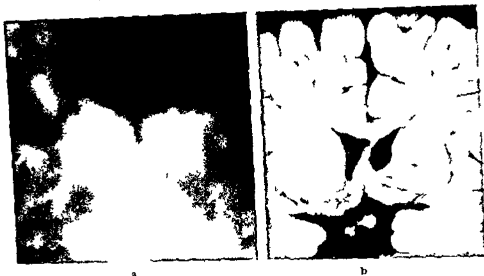


Fig 2 a) A p encephalogram showing small lateral ventricles and cortical atrophy b) Coronal section of the brain

the ventricles gradually change into irregular cavities as the frontal temporal, parietal and occipital lobes are formed This is connected with the growth and increase in volume of the caudate nucleus which intrudes into the lumen of the ventricle from the lateral aspect In the early period of development the ventricular walls are lined with a few layers of undifferentiated epithelial neuroectodermal cells The epithelium in the fifth month of foetal life becomes differentiated into a single layer of ependymal cells lying on the subependymal glia

Absence of segments of the ependyma of the third ventricle may occur as a developmental anomaly in adults

It seems that the ependymal fusions that determine the original size of a ventricle as well as the separation of ventricular parts by one layer of ependymal cells occur in the fifth to sixth month of foetal life when the growing caudate nucleus approaches the corpus callosum Under normal conditions both structures are separated from each other by the fissure like external angle of the ventricle If the two walls approach too closely, fusion between them may occur and it is possible that locally the ependyma may only partially form or even disappear (DAMBSKA)

These changes are difficult to interpret at encephalography especially in cases of cerebral atrophy when a small size of one or both lateral ventricles may be



Fig 1 a) A p encephalogram Asymmetry of the lateral ventricles b) Section of the brain Deformation of the lateral ventricles corresponding to the encephalographic changes

groups of ependymal cells suggesting ectopia (Fig 3c) Neither inflammatory changes nor reaction in the surrounding tissues were observed

Separation of large portions of the external angles of both ventricles occurred in a case not included in the series Ependymal fusions caused marked diminution in the size of both lateral ventricles (Fig 4) Encephalography was unfortunately not performed in this case

Discussion

The encephalographic and morphologic appearances of small lateral ventricles were first described by Davidoff in 1946 as coarctation of the walls of the lateral angles of the lateral cerebral ventricles They were also dealt with by Epstein (1953), Morel & Wildi (1954) and Bates & Netsky (1955)

Microscopy of the present cases suggested that the deformation and the small size of the lateral ventricles was of developmental origin The morphologic character of the changes may strengthen the belief that disturbances in the formation of the cerebral ventricles start during foetal life Development of the ventricular system begins, according to Barbe (1938), in the second month of foetal life The original ventricles appear in the shape of large, rounded, thin walled cavities filled with a plexus of choroid vessels The walls of the lateral ventricles thicken as they become transformed into the cerebral hemispheres, and

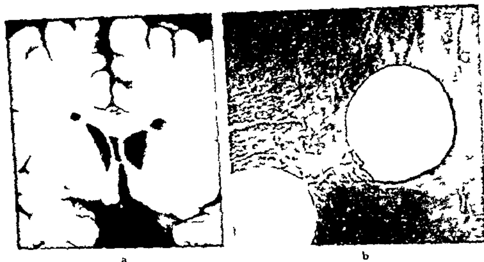


Fig 4 Coronal section of the brain Separation of large parts of the external angle of both lateral ventricles b) Photomicrograph The character and extent of the ependymal fusions between the corpus callosum and caudate nucleus are disclosed

SUMMARY

Small lateral ventricles without displacement is a not uncommon finding at routine encephalography Sixty post mortem encephalographies as well as gross and microscopic examinations of the brain were performed to determine the cause of deformation of the lateral ventricles due to *ependymal fusions* The investigations suggested that the changes are developmental in origin

ZUSAMMENFASSUNG

Bei der Enzephalographie findet man nicht selten kleine Seitenventrikel ohne Verschiebung Es wurden 60 Enzephalographien auf dem Sektionstisch vorgenommen sowie makroskopische und mikroskopische Untersuchungen des Gehirns um die Ursache der Deformation der Seitenventrikel durch die Fusion des Ependyms zu studieren. Die observierten Veränderungen deuten auf eine Entwicklungsmissbildung

RÉSUMÉ

Il n'est pas rare que l'encephalographie gazeuse montre de petits ventricules latéraux sans deplacement Les auteurs ont fait, pour determiner la cause de deformation des ventricules lateraux par fusion de l'ependyme soixante encephalographies post mortem et des examens microscopiques et microscopiques du cerveau Leurs recherches font penser que ce sont des malformations developpementales

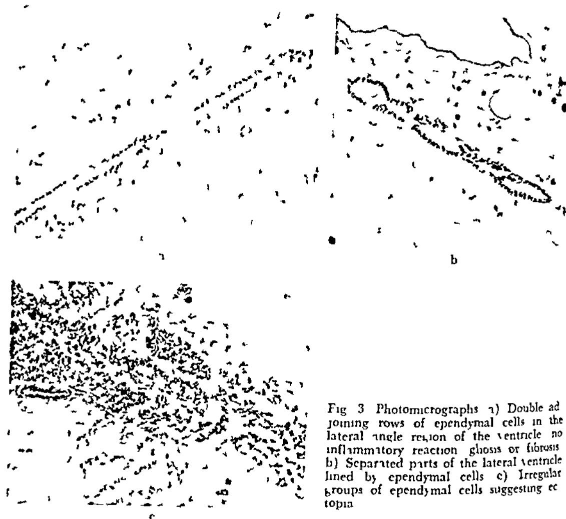


Fig 3 Photomicrographs a) Double adjoining rows of ependymal cells in the lateral angle region of the ventricle no inflammatory reaction gliosis or fibrosis b) Separated parts of the lateral ventricle lined by ependymal cells c) Irregular groups of ependymal cells suggesting ectopia

accompanied by marked cortical atrophy and widening of the third ventricle (KOZLOWSKI & DYMECKI 1966) It is reasonable to assume that this discrepancy between the degree of cortical atrophy and the size of the ventricles may be due to fusions between the corpus callosum and caudate nucleus limiting any increase in size of the ventricular system

The main radiologic signs of ependymal fusions are a small lateral ventricle with short upper and lateral walls, and sharpening of the apex, a double outline of this angle in a p views, and asymmetric position without displacement of the ventricular system The phenomenon of the double outline of the external angle in a p views is explained by the superposition of an enlarged anterior part of the frontal horn on a small ventricular body in cases in which the caudate nucleus does not reach the former

FROM THE ROENTGEN DEPARTMENT, UNIVERSITY AND STATE HOSPITAL, LAUSANNE, SWITZERLAND

HEIGHT OF FOURTH VENTRICLE

Normal variability during pneumography

by

R OBERSON G CANDARDJIS and N RAAD

The progressive dilatation of the fourth ventricle that constantly occurred during the first minutes of cerebral pneumography in a large material again drew attention to the true ventricular size and certain associated problems

Material Five hundred and sixteen cerebral pneumographies had been performed from July 1966 to July 1967 Four hundred posterior fossae in adults were studied in detail and twenty six were found to be pathologic Seventeen of the cases though radiologically considered normal have not been included in the material since clinically they had cerebellar or axial signs and thirty five cases were excluded for technical reasons Three hundred and twenty two examinations of the normal posterior fossa remained for review (see Table)

Method All the cerebral pneumographies were performed with the craniograph Mimer II with focus film distance 110 cm 0 6 mm focus Royal Blue Kodak film fixed grid 12 1 ratio and angle of cut for tomography 31° The object (the midline structures of the postero-inferior part of the brain) was 80 cm distant from the focus The magnification ratio was 1 375

The patient was seated in an Elema Schonander rotating chair The head was flexed forward so as to incline the orbitomeatal line 20° below the horizontal The first median sagittal tomogram for the demonstration of the fourth ventricle and aqueduct was obtained after injection of 7 ml oxygen Air was used in about

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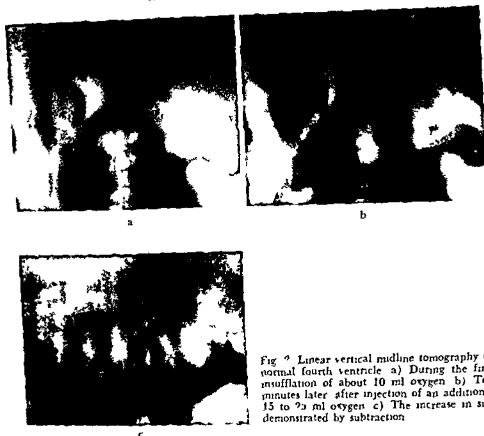


Fig 2 Linear vertical midline tomography of normal fourth ventricle a) During the first insufflation of about 10 ml oxygen b) Ten minutes later after injection of an additional 15 to 25 ml oxygen c) The increase in size demonstrated by subtraction

The progressive dilatation is easy to recognize in the lateral tomogram (Fig 2) but more difficult to observe in the p a view The third ventricle also seems to dilate This phenomenon of progressive dilatation of the fourth ventricle in the first ten minutes of pneumography is also demonstrable by the subtraction technique A positive film of the first tomogram is superimposed on the second tomogram printing of the two then reproduces only the margins of the increased fourth ventricle (Fig 3)

Discussion

The results more or less agree with those of AMUNDSEN who gave the mean value of the height of the normal fourth ventricle as 12.5 mm He disregarded the time between injection and exposure and paid no attention to whether the cisterns were filled or not this latter fact per se seems to be unimportant because

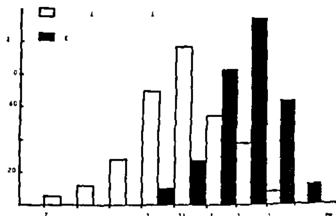


Fig 1 Distribution of measurements of the height of 322 normal fourth ventricles White blocks represent the height at beginning of insufflation black blocks the height at the end of the examination

a third of the examinations at the beginning of the series Immediately after the first tomogram, a p a view was obtained with the head of the patient in the same position, followed by a second exposure after injection of 10 to 20 ml oxygen to fill the ventricles and the cisterns, and then a lateral view was obtained The tomographic examination was completed after injection of a further 5 to 10 ml oxygen

Two tomograms are required for the determination of the height of the fourth ventricle one after injection of 7 ml and a second after injection of 22 to 32 ml oxygen about 10 minutes later The inclination of the head is the same and no cerebrospinal fluid is withdrawn

Measurements were made twice by two independent radiologists, and only the mean values have been used The height of the fourth ventricle according to AMUNDSEN is calculated from the fastigium and not from the superior posterio recesses These two distinctive anatomical features can always be recognized

Results

After injection of only 7 ml oxygen the height of the fourth ventricle in the midline tomogram varied between 7 3 and 13 8 mm, mean value 11 mm (all values corrected for magnification) In the second tomogram, the height was somewhat greater and varied between 10 9 and 14 5 mm, mean value 12 8 mm

The distribution of the measurements is given in Fig 1 No sex differences and only small variations in the age groups were observed The dilatation of the fourth ventricle was more obvious in patients under 50 years of age The mean progressive dilatation for the 322 patients was 1 8 mm but for those under 50 years of age it was 1 9 mm, and for the more elderly only 1 6 mm (see Table)

Table

Normal variability of the height of the fourth ventricle during pneumography (values corrected for magnification) — 1 standard deviation = 127

	Male	Female	Under 50 years	Over 50 years
Normal posterior fossae in 322 adults	219	103	180	142
Average height of the fastigium in mm				
after 7 ml O	11	11	10 9	11 4
after ? to 3? ml O	12 8	12 8	12 8	13
Average increase (main progressive dilatation)	1 8	1 8	1 9	1 6

Radiologic investigations Various authors have reported variations in the size of the lateral ventricles at pneumography COBBLE & BRACKETT usually found an enlargement but sometimes a diminution during the hour following pneumography These volumetric variations would have been smaller for the third ventricle JIROUT wrote of a reactional cerebral oedema as the cause of a diminution in the size of the ventricle immediately after insufflation the oedema gradually subsiding in the course of some hours The oedema was caused by the irritative effect of air, and films obtained 24 hours later therefore revealed the true size and shape of the ventricles These statements may be true for the lateral ventricles but not for the midline ventricular system It seems however as if JIROUT'S statements were mainly based on findings in abnormal cases He reported the changes to be greatest in patients with a history of closed injuries of the head

SCHATZKI et coll expressed the same opinions as JIROUT but BRONISCH did not rely on late film measurements PETROV distinguished three phases first a diminution then an enlargement at 20 to 30 hours following the procedure and finally a restitution This seems to be only an extension of the JIROUT theory LE MAY reported enlargement of the ventricles mainly during pneumography with air but in one case with oxygen due to variable partial tension coefficients in cases of cerebral atrophy and stated that it was reasonable to suppose that the 24 hour films reflect the normal ventricular size

The present study revealed that at the beginning of the examination the fourth ventricle was smaller than it was about 10 minutes later An average increase of 1 8 mm in the height of the fourth ventricle occurred but probably the whole capacity of the ventricle is increased No difference could be found between air and oxygen as the contrast medium The enlargement was more marked in patients under 50 years of age and almost never occurred when the fourth ven

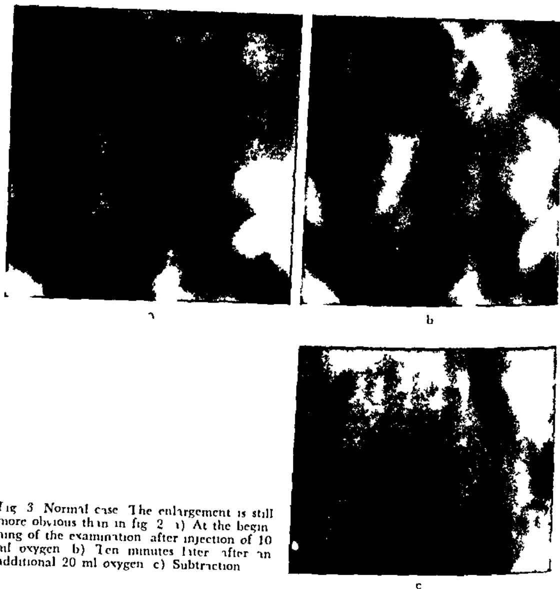


Fig. 3. Normal case. The enlargement is still more obvious than in fig. 2. a) At the beginning of the examination after injection of 10 ml oxygen. b) Ten minutes later, after an additional 20 ml oxygen. c) Subtraction.

the distribution may have been normal although it may have some bearing in considering the true size of the fourth ventricle.

Anatomical investigations. From the casts they had made, KNUDSEN, and LAST & TOMPSETT found that the volume of the fourth and third ventricles was relatively small. KNUDSEN gave a total volume of 1.5 ml (this included the aqueduct), and of this 0.85 ml (three fifths) was for the fourth ventricle. LAST & TOMPSETT's fourth ventricle was only of 0.72 ml volume, and these authors wrote that 'fixation does not appreciably alter the size or shape of the ventricles. The average linear shrinkage was under 2 %.

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RESORPTION DU PROTOXYDE D'AZOTE UTILISE COMME GAZ DE CONTRASTE AU COURS DES EXAMENS NEURORADIOLOGIQUES

par

C PHILIPPART

La vitesse de diffusion d un gaz vers un liquide est proportionnelle au gradient de pression partielle du gaz dans le milieu gazeux et le milieu liquide Elle est aussi proportionnelle a la solubilite de ce gaz dans le liquide envisage

C est pourquoi la resorption de l air utilise comme gaz de contraste est lente apres l encephalographie fractionnee la ventriculographie ou la myelographie gazeuse En effet l air contient 80 % d azote dont la solubilite dans les tissus et le sang est faible (sang 1 28 vol %) Par ailleurs si le patient respire aussi de l air la pression partielle de l azote dans l organisme est aussi elevee que dans l air utilise comme contraste

Deux methodes ont jusqu a present ete utilisees dans le but d activer la resorption du gaz de contraste

1 Lorsque le gaz injecte est de l air le patient est place apres l examen dans une atmosphere depourvue d azote et respire de l oxygene pur ou un melange compose d oxygene et d hélium (CLEVELAND et coll 1942 HAUKE et coll 1967)

2 On peut aussi injecter un gaz relativement soluble dans le sang et les tissus Parmi les gaz qui ont ete utilises experimentalement le protoxyde d azote pre-

tricle was already pathologically dilated This may be explained by a reduction in the elasticity of the cerebral parenchyma with increasing age and under certain pathologic conditions

SUMMARY

The height of the fourth ventricle was radiographically measured in a material of 322 normal adult skulls It was found to increase on an average from 11 mm to 12.8 mm during the early minutes of encephalography The first measurement appears to represent the true ventricular size

ZUSAMMENFASSUNG

Die Höhe des vierten Ventrikels wurde an einem Material von 322 normalen Schädelaufnahmen in Erwachsenen gemessen Es zeigte sich, dass während den ersten Minuten der Encephalographie das Durchschnittsmass von 11 mm auf 12,8 mm anstieg Das erste Mass muss als Norm angesehen werden

RÉSUMÉ

La hauteur du quatrième ventricule a été mesurée radiographiquement sur une série de 322 adultes normaux Les auteurs ont constaté qu'elle passe en moyenne de 11 mm à 12.8 mm au cours des premières minutes de l'encéphalographie La première mesure semble représenter la véritable dimension du ventricule

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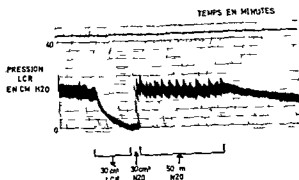


Fig 2 Myelographie gazeuse (inhalation d air injection de N_2O) Determination du volume de N_2O a injecter pour maintenir constante la pression dan les espaces sous arachnoidiens

Nous avons montre (PHILIPPART et coll 1966, 1967) que si le patient inhale 75 % de protoxyde d azote sous anesthesie generale le protoxyde d azote injecte comme contraste n est pas resorbe de façon evidente pendant toute la duree de l examen (Fig 1a 1b) Lorsque l examen radiologique est acheve on procede au reveil du patient et celui ci respire de l air On assiste alors a la disparition rapide du gaz de contraste (Fig 1c)

Ainsi nous avons reuni deux avantages le maintien d un gaz dans les espaces contrastes pendant l examen et son elimination rapide apres Ces experiences ont ete confirmees par celles de BERGSTROM et coll (1967)

L etude suivante a pour but (1) de montrer la vitesse avec laquelle le protoxyde d azote injecte comme contraste diffuse vers les poumons lorsque le patient respire de l air (2) de definir les roles que jouent le tissu cerebral les plexus choroides ventriculaires et les espaces sous-arachnoidiens dans l elimination du gaz de contraste et (3) de definir le risque de l injection et de la resorption de grande quantite de protoxyde d azote

Methode Nous avons etudie quinze patients Tous ces patients sont anesthesies et inhalent spontanement apres intubation tracheale de l air et 1 5 % de fluothane Apres le retrait d un volume variable de L C R un volume equivalent de protoxyde d azote est injecte comme gaz de contraste La pression dans les espaces contrastes est enregistree de façon continue a l aide d un capteur raccorde a un polygraphe La diffusion rapide du gaz de contraste vers les tissus le sang et les poumons se traduit par une chute de pression Pour empecher cette chute nous injectons de façon continue du protoxyde d azote Chaque minute les volumes injectes sont notes De cette façon nous pouvons evaluer la quantite de protoxyde d azote qui a diffuse

Les patients sont repartis en trois groupes de cinq

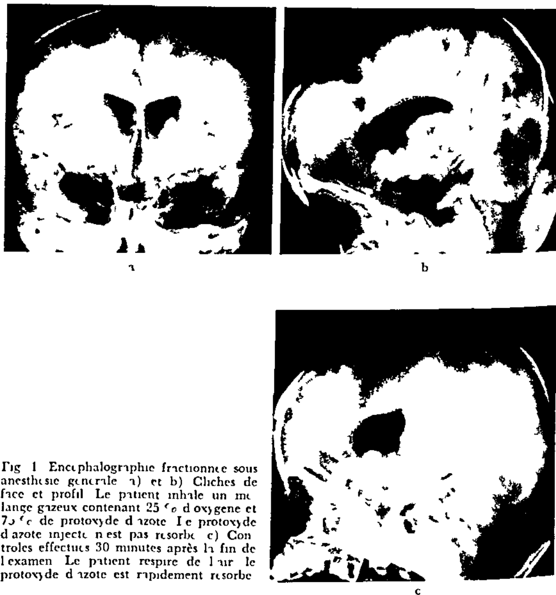


Fig. 1. Encéphalographie fractionnée sous anesthésie générale. a) et b) Clichés de face et profil. Le patient inhale un mélange gazeux contenant 25 % d'oxygène et 75 % de protoxyde d'azote. Le protoxyde d'azote injecté n'est pas résorbé. c) Contrôles effectués 30 minutes après la fin de l'examen. Le patient respire de l'air; le protoxyde d'azote est rapidement résorbé.

sente de nombreux avantages : c'est un gaz neutre, inoffensif et très soluble (sang : 45 vol %). Il permet d'obtenir un bon contraste radiologique (AIRD, 1936).

Malheureusement, la diffusion du protoxyde d'azote depuis les espaces contrastés vers le sang et les tissus, puis son élimination par les poumons, est cependant trop rapide si le patient respire de l'air, de telle sorte qu'on ne dispose pas d'un temps suffisant pour pratiquer l'encéphalographie gazeuse fractionnée (AIRD).

Resultats

Dans les quinze cas, l enregistrement de la pression presente une allure similaire (Fig 2) Les resultats chiffres de cette etude sont groupes dans un Tableau

Dans le groupe I la resorption du gaz au niveau des espaces sous-arachnoidiens de la convexite et des citernes est extremement rapide L etude de la corticalite par le protoxyde d azote est impossible si le patient respire de l air D autre part nous n avons pas observe d embolie gazeuse en depit des grandes quantites de protoxyde d azote resorbees par unite de temps

Dans le groupe II, au cours de la ventriculographie le protoxyde d azote injecte se localise dans les cornes frontales le patient est en decubitus Nous nous sommes aperçus que si le niveau hydro-aerique reste localise au dessus des trous de Monro la pression du L C R ne diminue pas tandis que l image radiologique observee en television ne montre pas de modification Nous pouvons en conclure que la diffusion directe du gaz depuis les ventricules vers le parenchyme cerebral est insignifiante Les signes de diffusion n apparaissent que lorsque le niveau hydrogazeux descend au dessous des trous de Monro c est a-dire la ou le gaz est en contact avec les plexus choroides Chez ces malades qui avaient tous une dilatation du systeme ventriculaire des quantites importantes de protoxyde d azote ont du etre injectees pour atteindre ce niveau Meme alors des volumes relativement faibles de protoxyde d azote ont diffuse

Dans le groupe III au cours de myelographie nous avons realise des echanges L C R — protoxyde d azote d une importance aussi grande que dans les ventriculographies (groupe II) Mais nous avons ete obliges d injecter de façon continue des quantites plus importantes de protoxyde d azote afin de maintenir la pression constante au cours de l examen Ces quantites sont neanmoins inferieures a celles injectées chez les malades du groupe I

Conclusions

Cette etude permet de conclure

1 Il est necessaire pour pratiquer l encephalographie au protoxyde d azote de faire inhaler du protoxyde d azote et non de l air

2 La resorption du gaz se fait plus rapidement au niveau des espaces sous arachnoidiens que dans le systeme ventriculaire Dans les ventricules c est au niveau des plexus choroides que la resorption se fait surtout

3 Il n y a pas de risque d embolie gazeuse lorsqu on injecte de grandes quantites de protoxyde d azote dans les espaces sous-arachnoidiens et le systeme ventriculaire meme quand le patient respire de l air et que la resorption du gaz de contraste est rapide

Tableau

Injection continue de N_2O dans l encéphalographie la ventriculographie et la myélographie gazeuses

Malade No	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
Gaz de contraste	N_2O					N_2O					N_2O				
Gaz inhalé	Air					Air					Air				
Espaces contrastes	Corticalite et citernes					Ventriculographies					Myelographies				
Pression initiale (en cm H_2O)	56	68	69	55	50	30	22	20	38	26	15	15	17	30	20
L CR retiré (en ml)	20	30	20	20	20	40	35	50	61	45	60	30	60	45	30
N_2O injecté (en ml)	20	25	20	20	20	50	50	60	51	55	60	40	70	45	30
Pression résultante (en cm H_2O)	53	62	68	53	50	28	28	28	36	30	15	20	18	30	20
Volume N_2O injecte (en ml) Après 2	15	15	10	10	12						10	14	15	16	10
Après 5	44	38	47	25	28	10	5	10	5	6	30	32	30	25	25
Après 10	82	73	90	50	55	20	10	20	10	12	60	45	45	45	50

Groupe I Le gaz est injecte par voie lombaire et dirige vers les espaces sous arachnoidiens des citernes et de la convexite, les patients sont assis et maintenus la tête en hyperextension La pression est enregistree grâce a une seconde aiguille placee sous la premiere, dans la region lombaire

Groupe II Le protoxyde d azote est injecte de façon directe dans les ventricules cerebraux Ces patients sont en decubitus la pression est enregistree par une des deux aiguilles ventriculaires

Groupe III Le protoxyde d azote est injecte par voie sous occipitale afin de proceder a une myelographie gazeuse Les patients sont en position de Trendelenburg lateral, la pression mesuree a l aide d un aiguille placee dans la region lombaire

Avant de proceder a ces experiences, nous nous sommes assures de la sterilite du protoxyde d azote (L etude bacteriologique a ete faite par J Bassleer, Directeur du Service d Hygiene de l Institut Provincial E Malvoz)

D autre part, nous avons construit un appareil de detente permettant d amener le gaz a une pression voisine de la pression initiale du L C R du patient et a une temperature identique a celle du local Cet appareil est sterilise a l autoclave avant chaque examen

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SOUSTRACTION D IMAGE EN ENCEPHALOGRAPHIE

par

G RUGGIERO et M MAZZACURATI

Dans des travaux precedents (RUGGIERO & MAZZACURATI 1967) nous avons decrit un appareillage pour la soustraction en encephalographie en insistant sur les difficultes de cette technique En particulier l appareil bien qu il eut pu nous fournir des soustractions acceptables s etait revele difficile a manier et par consequent inutile dans la pratique Le but de ce travail est de presenter le nouveau modele

L appareillage comporte deux elements un element fixe tete (Fig 1) et un element de soutien (Fig 2) Ce dernier est fixe au Mimer et permet de bouger le crane suivant des positions donnees qui seront utilisees d abord pour les radiographies destinees a la preparation des masques et ensuite pour les radiographies avec contraste destinees a la soustraction La figure (Fig 3) montre ces deux elements montes sur un malade Une description plus detaillee nous ne semble pas utile car le fonctionnement de l appareillage ne saurait etre veritablement demontre que par un film

Les resultats obtenus ne sont pas encore de la qualite esperee car l utilisation de l appareil n est pas encore assez rapide pour en permettre l emploi chez des malades ayant par exemple une hypertension intracranienne et ou l examen doit etre fait tres vite De plus cet appareillage doit etre complete par un systeme de centrage optique automatique qui n est pas encore pret Toutefois les

RÉSUMÉ

Dans les explorations neuroradiologiques avec moyen de contraste gazeux, le N_2O injecté comme gaz de contraste est rapidement éliminé par le sang et les poumons si le patient respire de l'air. La résorption du gaz est plus rapide au niveau des espaces sous-arachnoïdiens. Dans les ventricules cérébraux, la résorption se fait surtout par l'intermédiaire des plexus choroïdes. Le N_2O injecté ne se résorbe pas sous anesthésie générale si le patient inhale 75 % de N_2O.

SUMMARY

N_2O is rapidly resorbed and eliminated with the expired air in neuroradiologic investigations with gas as contrast medium, when the injection of N_2O takes place while the patient is breathing air. Gas in the subarachnoid spaces is more rapidly resorbed than gas in the cerebral ventricles, where the resorption takes place via the choroid plexus. N_2O is not resorbed if it is injected while the patient is breathing 75 % of N_2O under general anesthesia.

ZUSAMMENFASSUNG

In neuroradiologischen Untersuchungen mit Gaskontrastmittel und wenn die Injektion von N_2O während Luftinhalation des Patienten vorgenommen wird, so wird N_2O schnell resorbiert und mit der Ausatmungsluft eliminiert. Gas in den Subarachnoidalräumen wird schneller resorbiert als Gas in den Gehirnventrikeln, wo es durch den Plexus chorioideus resorbiert wird. Wenn die Injektion von N_2O während Anästhesie erfolgt und der Patient 75 % des Gases inhaliert, wird N_2O nicht resorbiert.

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a b

Fig. 4 En projection laterale le troisieme ventricule et surtout son plancher est mieux demontre par la soustraction (b)



a b

Fig. 5 En projection antero-posterieure la soustraction (b) donne une meilleure definition des parois latérales des cornes frontales surtout à gauche et permet de dissocier plus aisement l'image des espaces sous-arachnoidiens frontaux.

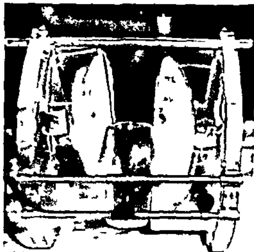


Fig. 1. Appareil fixe-tête. Il s'agit de deux demi-calottes de butyrate de cellulose fixés à un support en plexiglas. Ces deux demi-calottes peuvent être rapprochées, éloignées ou changées suivant les dimensions de la tête du malade.

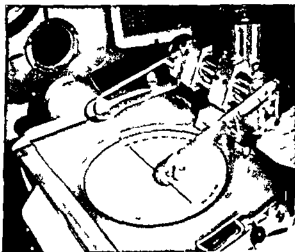


Fig. 2. Appareil de soutien. Deux bras en plexiglas très épais fixés à un ensemble mécanique qui en permet l'adaptation à l'appareil fixe-tête qu'ils solidarisent avec le Mimer. Par cet ensemble la tête est maintenue immobile dans l'appareil fixe-tête et peut être déplacée suivant les plans orthogonaux.

soustractions que nous avons pu réaliser avec cet appareil nous ont confirmé la validité de la méthode, ainsi que le démontrent les Figs 4 et 5. Les radiographies obtenues ont prouvé l'utilité de la technique aussi pour l'étude des citernes de la fosse postérieure et du tronc cérébral, ainsi que des cornes frontales. Ces exemples s'ajoutent à ceux déjà publiés où l'on montrait la possibilité d'utiliser la soustraction pour différencier l'espace sous-arachnoïdien du système ventriculaire et, surtout, de récupérer un mauvais cliché comme on le fait pour l'angiographie cérébrale (RUGGIERO & DETTORI 1967).

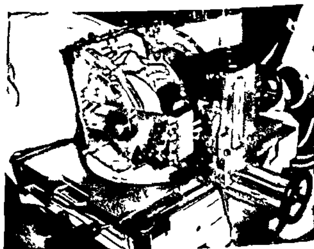


Fig. 3. Appareil fixe-tête et appareil de soutien montés sur un malade.

FROM THE UNIVERSITY HOSPITAL ANN ARBOR, MICHIGAN, U S A AND L'HÔPITAL FOCH PARIS (SURESNES) FRANCE

DELIMITATION OF THE VENTRAL POSTERIOR NUCLEUS OF THE THALAMUS

Comparison of radiologic and electrophysiologic techniques

by

J FAREN G GUIOT P DEROME and J C TRIGO

Stereotaxic surgery requires the following steps (1) establish the radiologic coordinates of the target (2) reach the target by precision apparatus over an appropriate route (3) corroborate the target neurophysiologically (4) destroy the target To eliminate the step of neurophysiologic target corroboration is to increase the hazards to the patient

In Parkinson s disease tremor and rigidity can be totally eradicated without neurologic deficit if the surgical lesion is confined to the ventral lateral nucleus of the thalamus which includes the ventral oral posterior the ventral oral anterior and the ventral intermedius divisions (HASSLER & RIECHERT 1954) Extension of the lesion posteriorly into the ventral posterior nucleus of the thalamus may produce paresthesias inferiorly into corpus Luysi ballismus anteriorly into the anterior one-quarter of the posterior limb of the internal capsule containing frontothalamic and frontopontine fibers mental changes laterally into the motor area of the internal capsule spasticity and dysarthria medially into the dorso-median and mamillo-thalamic bundle mental changes inferiorly into brachium conjunctivum excessive hypotonia and lateropulsion (Figs 1 2 and 3) For abbreviations in the illustrations see accompanying list

RÉSUMÉ

Description de dispositifs accessoires pour la radiographie avec soustraction en encéphalographie.

SUMMARY

Description of accessory equipment for use in encephalography with radiographic subtraction.

ZUSAMMENFASSUNG

Zusätzliche Ausrüstung zur Anwendung bei Encephalographie mit radiographischer Subtraktion wird beschrieben.

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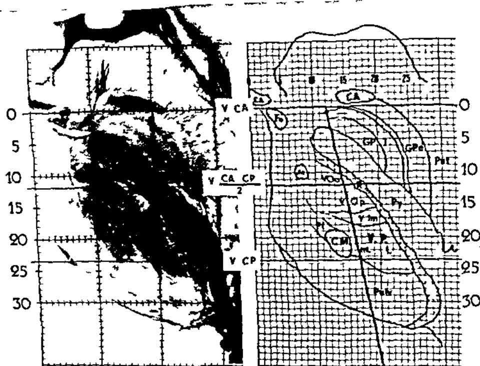


Fig 2 Horizontal section in the plane of the trajectory On the right is a drawing of the section with the trajectory ind cated by an arrow V CA, V CP and V and CA CP/2 are l nes of three vertico-frontal planes perpendicular to the CA CP baseline For other symbols see list of abbreviations below

List of abbreviations

A	Anterior nucleus	M	Foramen of Monro
Az	Mamm llo-thalamic tract (fascicle of Vicq d Azyr)	Ni	Substantia nigra
O T	Optic tract	Pul	Pulvinar
C A	Anterior commissure	Put	Putamen
C P	Posterior commissure	Pf	Parafascicular nucleus
Int Cap	Internal capsule	Py	Pyramidal tract
Cau	Caudate nucleus	R	Reticular nucleus (zone grillagee)
C M	Mammillary body (corps mam llaires)	R	Red nucleus
C M	C ntre median	V Im	Intermediate ventral nucleus
D M	Dorso-median nucleus	V O a	Anterior ventral-oral nucleus
Fo	Fornix	V O p	Posterior ventral-oral nucleus
G P	Globus pallidus i (internal) e (external)	V P	Posterior ventral nucleus m (medial) l (lateral)
L	Subthalamic nucleus (corpus Luys)	Z I	Zona incerta

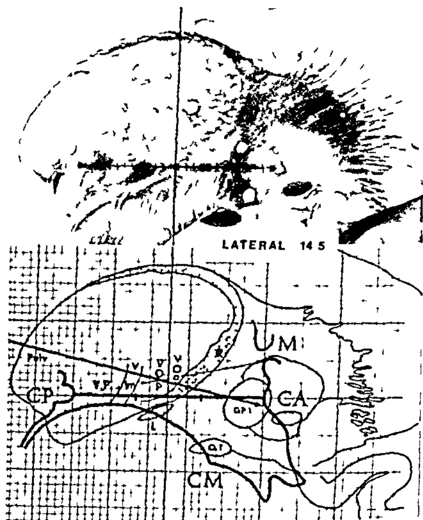


Fig 1 Parasagittal section of a human brain 14 5 mm from the midline crossing the target center Below is a drawing of this section and the superimposed outline of the third ventricle Each division of the grid is one millimeter trajectory is indicated by the arrow

The coordinates of length and height of the target are obtained from the lateral ventriculogram and that of laterality from the frontal ventriculogram These measurements must be corrected for any magnification The anterior commissure, the posterior commissure, and the foramen of Monro are identified on the lateral ventriculogram and a bicommissural CACP line established (Fig 4) The outlines of the thalamic nuclei can then be constructed by the method of TALAIRACH et coll (1950, 1952) using proportional values based on the height of the individual thalamus and the division of the CACP line into thirds (Fig 5) The anterior border of the VP nucleus is represented by an oblique line uniting

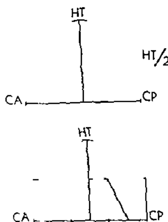


Fig 5 Schematic construction of a lateral projection of the ventral thalamic nuclei *Upper part* The anterior and posterior commissures are joined by the CA CP line which represents the inferior edge of the ventral nuclei A perpendicular from the midpoint of this line to the floor of the lateral ventricle represents the thalamic height (HT) A line parallel to CA CP at the middle of the thalamic height (HT/2) separates the ventral nuclei from the dorsal nuclei posterior to the perpendicular line at the middle of CA CP *Lower part* CA CP is divided into three equal parts and two vertical lines are drawn between CA CP and HT/2 the first one at the junction of the posterior and middle thirds of CA CP the second one at CP An oblique line uniting the point of junction of the first vertical line with HT/2 and the midpoint of the posterior third of CA CP is the anterior border of the ventral posterior nucleus (VP) The other limits of this nucleus are superiorly HT/2 inferiorly CA CP posteriorly V CP

the point of junction of the first vertical and HT/2 and the midpoint of the posterior third of CACP Since the coordinate of laterality is the most difficult to ascertain precisely radiologically the third ventricle being variable in width and irregular (the target area facing the narrowest part) and the frequency of a massa intermedia a neurophysiologic confirmation of the target has perhaps its greatest justification here

The posterior to anterior trajectory has been used in over a thousand patients at the Foch hospital It has the advantages over a coronal trajectory in that it crosses all the ventral nuclei (which can then be electrophysiologically differentiated delineating the targets precisely) and several structures can be destroyed

Target localization requires an accuracy of plus or minus one millimeter Currently only exploration of the VP nucleus electrophysiologically delineation of the internal capsule or both give this precision (ERVIN *et coll* 1960) GUIOT et coll (see ALBE FESSARD et coll 1961, 1962 1963 GUIOT et coll 1962) first described the precise identification and delimitation of the structures through which the electrode penetrated A bipolar semi microelectrode records both spontaneous and evoked electrical activity (Fig 6) The VP nucleus displays an extreme density of spikes and specific tactile evoked potentials can be recorded The disappearance of the evoked responses characterizes entry of the electrode into the V Im nucleus A definite pattern of tactile evoked response on the VP nucleus of man was first shown by DEROME (1962) (Fig 7) The target area in the VL nucleus for the relief of upper extremity symptoms lies just in front of the tactile representation of the thumb and the labial commissure on the VP nucleus If the evoked responses are recorded from the tongue the electrode is

Fig 3 Frontal section in the plane indicated by the arrow in the diagram at the bottom right On the upper right is an overlay of this section with the thalamic target cross hatched For symbols see list of abbreviations p 211

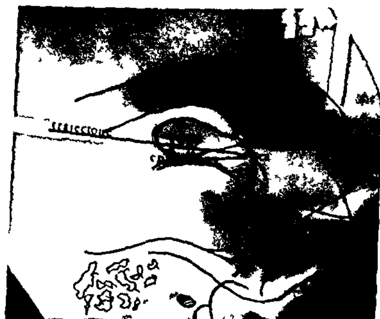


Fig 4 A retouched lateral ventriculogram to show the foramen of Monro anterior commissure and posterior commissure and to illustrate the construction of a CA CP line and the VP nucleus For symbols see list of abbreviations p 211

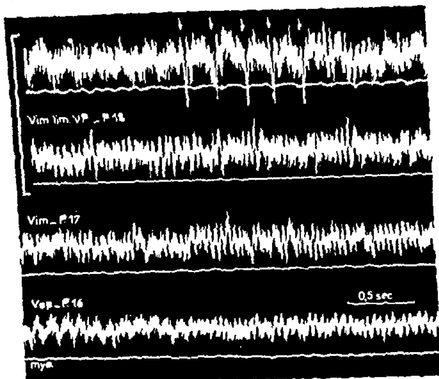


Fig 6 b Record of electrical activity from a bipolar semi microelectrode during traversal of the VP nucleus in the course of an operation for Parkinson's disease An oscilloscopic recording The small arrows indicate the inversion of tactile evoked potentials as the electrode leaves the VP nucleus and the disappearance of these evoked potentials as the electrode enters the Vim nucleus

evoked potentials are inverted and anteriorly by entry into the internal capsule where the spikes disappear

Ninety five consecutive cases of Parkinson's disease in which the target was chosen radiologically and confirmed neurophysiologically were studied to compare the accuracy of the two techniques All cases were successfully palliated no permanent complication was observed Indeed in the more than 600 cases operated upon with neurophysiologic control complications are rare The anterior border of VP as obtained radiologically and electrophysiologically was compared (Fig 8) Radiologic measurements placed this from 15 5 mm to 23 mm posterior to the anterior commissure approximately 70 % were between 17 and 19 mm with a median at 18 34 mm Tactile-evoked responses gave a spread of 15 5 to 25 mm 70 % of the cases were between 19 and 21 mm with a median at

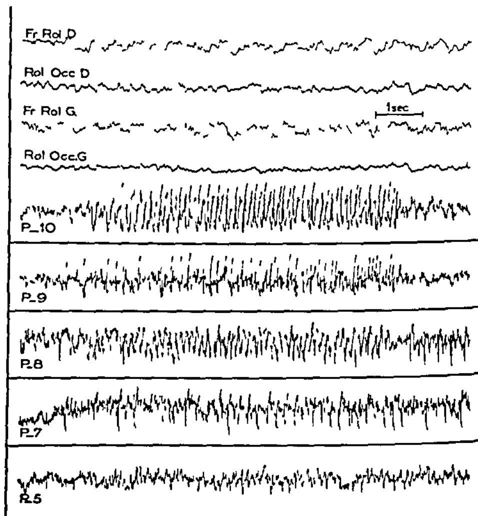


Fig 6 a Record of electrical activity from a bipolar semi microelectrode during traversal of the VP nucleus in the course of an operation for Parkinson s disease An EEG tracing to show tactile evoked potential from the labial commissure as the electrode crosses the medial part of the VP nucleus These first appear at frame P 10 and invert by frame P 9 and disappear in the final frame as the electrode exits from VP

too medial, if these are recorded from the fourth and fifth digits, it is too lateral To relieve symptoms involving the lower extremity, tactile evoked responses should be obtained from the fourth and fifth digits prior to entering the target area, for mandibular tremor, from the lips Therefore any error in laterality can be corrected prior to making a lesion since the evoked responses from the tactile zone of the VP nucleus give the precise electrode position The posterior extent of the target is represented by the anterior edge of the VP nucleus where the tactile

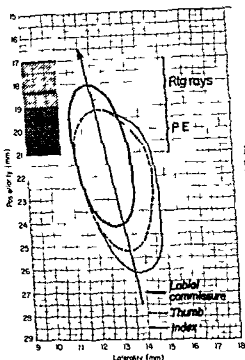


Fig 8 Statistical representation of the VP nucleus in the horizontal plane The anterior border of VP as determined from radiologic measurement is at 17 to 19 mm posterior to the anterior commissure in 70 % of the cases The solid line at 18 34 mm represents the median of all cases The anterior border of the VP as determined from tactile evoked potentials is represented by the cross-hatched area extending from 19 to 21 mm posterior to the anterior commissure in 70 % of the cases The median is shown by the heavy line at 19 5 mm. Each elipsoid encompasses approximately 60 to 70 % of the tactile evoked potentials recorded from the VP nucleus by light touch to the labial commissure thumb and the index finger

radiologic coordinates of laterality would be outside the target area 30 to 40 % of the time

Conclusion

Correct target delineation requires both radiologic and electrophysiologic techniques which can be likened to the use of a coarse and fine focus of a microscope in the identification of a specific field Our study suggests that to ignore neurophysiologic target corroboration may add a risk of 30 to 40 % morbidity which is not acceptable in a palliative procedure Tremor and rigidity of Parkinson s disease can be ablated without complication provided the lesion is made in a sharply circumscribed target Poor results arise from improper lesion placement rather than the efficacy of the target The percentage of successful results probably accurately reflects the degree of precision since any complication must be blamed on the technique Nowhere is this more true than in the case of bilateral thalamectomy the bilateral lesion if properly located is effective and safe it is the bilateral error that is dangerous

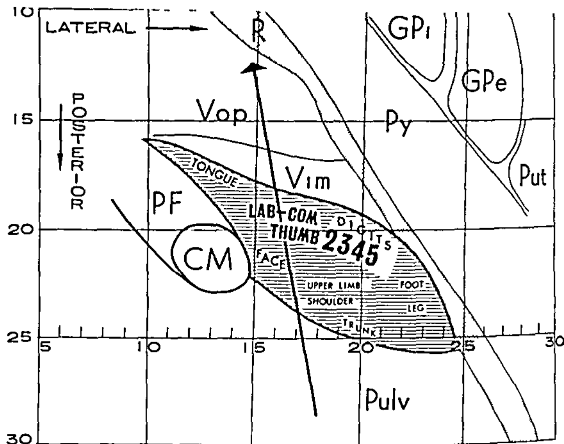


Fig 7 Schematic drawing of the somatotopic pattern of the tactile representation on the posterior ventral nucleus in a horizontal section The VP nucleus is horizontally striped the scale is divided in millimeters The heavy arrow represents the ideal trajectory

19 50 This suggests the lesion would be made too anterior in 70 % of the cases if based only on radiologic techniques However, more important, in the remaining 30 % of the cases an even greater error would be made The irregularity of the VP nucleus probably accounts for this disparity since the anterior border of VP is oblique in horizontal and parasagittal sections In 37 of the cases, or 38 %, a correction of 2 to 3 mm of laterality was necessary before the target area could be electrophysiologically confirmed The irregularity of the third ventricle, the presence of a massa intermedia or variability in the size of nuclear groups probably accounts for this Approximately 60 to 70 % of the tactile evoked potentials obtained from labial commissure, thumb and index finger were within the elipsoids depicted and agree remarkably well with the pattern as established in man by DEROME However, the 30 to 40 % of evoked responses that were scattered outside these elipsoids suggests that lesions based purely on

ANGIOGRAPHY

DEBITMETRIE CAROTIDIENNE COMPLEMENTAIRE DE L'ANGIOGRAPHIE CEREBRALE

par

M Aulhan D Dilenge, J Perilhou et J Metzger

Parmi les developpements recents de l'angiographie on peut citer l'emploi conjoint de l'etude de la circulation cerebrale aux rayons roentgen et de la mesure du debit sanguin au niveau de la carotide Cette mesure permet en effet de lever certains doutes laisses par la seule etude angiographique

La question se pose alors de savoir quelle methode utiliser pour effectuer la debitmetrie sanguine De toutes façons les methodes trop sanglantes necessitant la mise a nu du vaisseau sont a eliminer puisqu'on veut faire des mesures cliniques parallelement a toutes les angiographies Il n'est donc pas question d'utiliser ni les debitmetres electromagnetiques ni les debitmetres a ultrasons Reste le debitmetre a thermistance dont l'emploi serait possible si l'on pouvait utiliser pour introduire la thermistance la meme aiguille que celle qui sert a l'injection du produit de contraste Mais de toute façon ce genre de debitmetre mesure la vitesse du sang et non son debit Il faut alors faire des hypotheses sur la nature du regime de l'ecoulement sanguin pour determiner le debit C'est la une cause d'imprecision d'autant plus grande que l'on a souvent affaire a des vaisseaux malades et que des defauts de ces vaisseaux peuvent perturber le regime d'ecoulement

C'est pourquoi nous avons du mettre au point une nouvelle methode apte a fournir dans tous les cas et quel que soit l'etat de l'artere le debit sanguin et non la vitesse du sang en un point

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SERVICE DE NEURORADIOLOGIE (PROF H FISCHGOLD), HOPITAL DE LA PITIE PARIS ET DEPARTEMENT LEREM MASSIOT PHILIPS COURBEVOIE FRANCE

SUMMARY

Target delineation in the stereotaxic surgical treatment of Parkinson's disease requires both radiologic and electrophysiologic techniques A study comparing the radiologically determined coordinates of the target with those coordinates neurophysiologically obtained suggests that to ignore neurophysiologic target corroboration may add a risk of 30 to 40% morbidity to this palliative procedure

ZUSAMMENFASSUNG

Fur die Target Bestimmung bei der stereotaktisch chirurgischen Behandlung der Parkinson schen Krankheit sind radiologische sowie elektrophysiologische Methoden erforderlich Eine Vergleichsuntersuchung der radiologisch bestimmten Koordinaten des Targets mit den neurophysiologisch erzielten Koordinaten ergab, dass falls eine neurophysiologische Target Korroboration versaumt wird dieses palliative Verfahren mit einem 30 bis 40 prozentigen Morbiditatsrisiko verbunden ist

RÉSUMÉ

La delimitation de la cible dans le traitement chirurgical stéréotaxique de la maladie de Parkinson nécessite des techniques radiologiques et des techniques electro-physiologiques Une étude comparant les coordonnées de la cible determinées radiologiquement avec les coordonnées obtenues par la methode neurophysiologique montre que l'absence de confirmation neurophysiologique du siege de la cible peut grever cette methode palliative d'un risque de 30 à 40 % de morbidité

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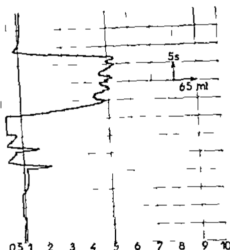


Fig 3 Enregistrement du debit carotidien d un malade

Ainsi que le montre Fig 1 l appareil comporte deux aiguilles qui sont introduites dans la carotide de l homme malade sans denudation de l artere, en utilisant la technique employee d une façon tres courante pour l injection de produit de contraste lors des angiographies carotidiennes

Les deux aiguilles debouchent a quelques centimetres l une de l autre La premiere sert a l injection d une quantite connue de serum froid a une temperature Ti connue La seconde preleve en aval de la premiere la meme quantite de melange sang serum dont on mesure la temperature Ta

En ecrivant le bilan thermique des echanges dans le vaisseau on trouve que le debit D de l artere est lie au debit d d injection de serum et d absorption de melange par la formule

$$D = d\frac{Ta - Ti}{Ts - Ta}$$

Ts etant la temperature du sang en amont des deux aiguilles, on la mesure au moyen d une sonde rectale Les trois temperatures sont mesurees par des thermocouples L enregistrement du debit D est effectue directement par l appareil au moyen d un quotient metre electronique apres amplification des tensions issues des thermocouples

Les aiguilles employees etaient les memes que celles utilisees couramment dans les angiographies Les thermocouples etaient du type coaxial etire sous gaine d acier de 0 5 mm de diametre ils etaient places dans les cones de raccordement des aiguilles Les amplificateurs etaient des amplificateurs a choppers electroniques a faible derive car les tensions doivent etre mesurees a quelques microvolts

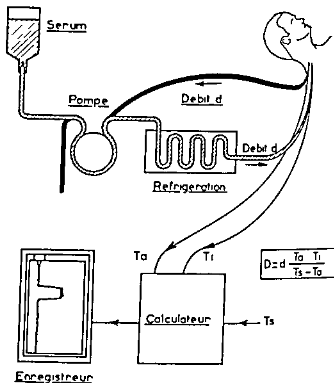


Fig 1 Dessin schematique du debitmetre

Fig 2 Photographie du debitmetre en ordre de marche

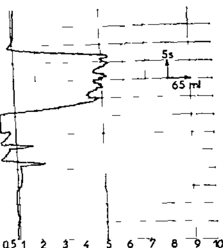


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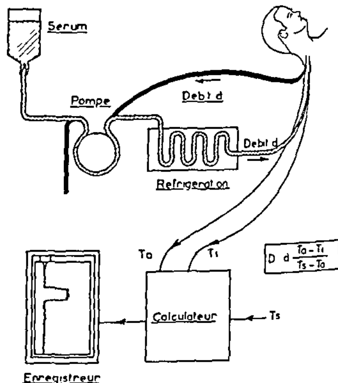


Fig 1 Dessin schematique du debitmètre

Fig 2 Photographie du débitmetre en ordre de marche

dependait pas de la distance entre les deux aiguilles du moment que celle-ci restait comprise entre 4 et 10 fois le diametre du vaisseau

La courbe de la Fig 3 est un exemple d enregistrement de debit carotidien et le Tableau p 222 indique les debits mesures sur 12 patients Nous possedons aussi les angiographies de tous ces patients On insiste sur le fait que l injection du produit de contraste se fait par une des aiguilles servant a la debitmetrie

A l heure actuelle les resultats cliniques sont encore provisoires car nous esperons les completer par un perfectionnement de la methode Ils nous semblent deja significatifs dans la mesure ou ils sont mis en rapport avec les donnees connues dans ce genre de recherche

RÉSUMÉ

Le resultat angiographique obtenu jusqu ici dans l etude de la circulation cérébrale peut etre valorise et rendu plus significatif grace a des mesures du debit sanguin au niveau des carotides Les auteurs discutent les méthodes existantes pour effectuer la mesure du debit d un vaisseau Ils présentent une nouvelle methode par dilution comportant une aiguille d injection de serum froid et une aiguille d absorption Cette methode a été appliquee au cours de 12 angiographies carotidiennes L injection du produit de contraste se fait par l une des deux aiguilles ce qui rend presque simultanement la debimétrie et l angiographie

SUMMARY

The results in angiographic studies of the cerebral circulation may be improved by simultaneous measurement of the blood flow at the level of the carotid arteries A new dilution method used in 12 carotid angiographies is described Injection of cold serum is made with one needle and another needle is used for absorption By injection of contrast medium throu h one of the needles flow studies and angiography can be performed almost simultaneously

ZUSAMMENFASSUNG

Die Ergebnisse angiographischer Untersuchungen der Gehirnzirkulation mogen sich durch gleichzeitige Messungen des Blutstroms auf der Hohe d r Carotiden verbessern lassen Eine neue Verdunnungsmethode die bei 12 Karotisangiographien verwendet wurde wird beschrieben Dabei wird kaltes Serum durch eine Kanule injiziert wahrend durch eine andere Kanule die Messungen durchgefuhrt werden Durch Injektion von Kontrastmittel durch die eine Nadel konnen Messungen der Durchblutung und die Angiographie beinahe gleichzeitig ausg fuhrt werden

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Tableau

Mesures effectuées sur 12 patients

N	Sexe	Âge (ans)	Carotide	Débit carotidien (cm/mn)
1	F	31	P	140 à 190
2	M	32		250
3	M	32	P	420 à 560
4	M	21	P	330
5	M	64	P+I	300
6	M	52	P	390
7	M	39		325
8	M	29		300
9	F	43		260
10	M	43	I	325
11	M	53	P	260
12	M	65	I	390

près. De plus, il y a pour chaque amplificateur un système de rattrapage automatique de zéro constitué par un petit moteur électrique entraînant un potentiomètre.

Le quotient mètre fonctionne analogiquement, il est constitué également d'un potentiomètre couplé à un moteur. On s'arrange pour renvoyer à l'entrée du moteur une tension de nature à déplacer le potentiomètre, de façon à ce que sa résistance comparée à une résistance fixe soit dans le même rapport que les deux différences de tensions obtenues par les 4 thermocouples (le thermocouple mesurant la température d'absorption est en effet double). L'axe du potentiomètre commande en même temps le stylet de l'enregistreur.

Pour que la mesure soit exacte, il faut que le débit d'injection d soit imposé avec précision. On utilise à cet effet une pompe péristaltique étudiée spécialement et comportant 6 galets de façon à éviter les à coups dans le débit. Ces galets écrasent des tubes en caoutchouc de silicone entoilé, la gaine de toile ayant pour rôle d'empêcher l'allongement de ces tubes et la diminution de débit qui en seraient la conséquence. Quant au moteur de la pompe, sa vitesse est régulée électroniquement à la valeur choisie par un sélecteur. Ces éléments sont visibles sur la Fig. 2 qui est une photographie de l'appareil.

La précision de la mesure est limitée par l'homogénéité du mélange entre le sérum injecté. Les vérifications du débitmètre n'ont pu être faites que sur des fantômes imitant la circulation du sang car dans les mesures in vivo, même sur un animal, nous n'avions aucun moyen de confronter le débit indiqué par notre appareil au débit réel. Les tests sur fantôme ont montré que le nombre lu ne

Table 1

Occlusion of a cerebral artery without infarction in the infarct series of 100 cases

Site of occlusion	Number of cases	Extracranial disease	Hypertension	Myocardial infarct
Distal to circle of Willis	6	1	3	2
Within circle of Willis	2	0	2	0

Table 2

Occlusion of a cerebral artery without infarction in the control series of 53 cases

Site of occlusion	Number of cases	Extracranial disease	Hypertension	Myocardial infarct
Distal to circle of Willis	1	1	0	0
Within circle of Willis	3	1	3	1

further two cases with symptoms of cerebral ischaemia but no infarct an occluded artery was present Six of the 53 cases in the control series were found to have occlusion without infarction

The occlusion in each case was by either atheroma or thrombus

Thirteen separate occlusions were present in the eight cases in the infarct series In one case the anterior cerebral artery was occluded and in two the pericallosal artery Two occlusions were found in a major branch of the middle cerebral artery In five cases the posterior cerebral artery or a major branch was occluded one being proximal to the posterior communicating artery A posterior communicating artery was occluded in one case

In the two cases with cerebral symptoms following occlusion but with no demonstrable brain infarction one occlusion involved the posterior cerebral artery proximal to the posterior communicating artery while the second revealed occlusion of a middle cerebral artery and the contralateral anterior cerebral artery

In the control series two anterior cerebral arteries were occluded Bilateral posterior cerebral artery occlusion occurred in one case and in another the same artery was occluded proximal to the posterior communicating artery The posterior inferior cerebellar artery was occluded in one instance and a basal perforating artery in two cases

Occlusions distal to the circle of Willis will be discussed separately to those within the circle of Willis

The findings in the infarct series are summarized in Table 1 In the ...

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PATHO-ANGIOGRAPHIC STUDY OF OCCLUSIVE DISEASE OF THE SMALLER INTRACRANIAL ARTERIES

by

J. P. BALMER and W. H. T. SHEPHERD

Although the leptomeningeal anastomoses on the surface of the brain were described by HEUBNER in 1874, their importance as a source of collateral supply was first stressed by VAN DER EECKEN & ADAMS in 1953. In the past decade, these anastomoses in living subjects have been demonstrated by cerebral angiography after cerebro-vascular accidents. Few cases have occasionally been documented, however, in which the leptomeningeal anastomoses have provided an adequate circulation and prevented ischaemic changes following the occlusion of a cerebral artery.

This paper is based on observations made during an autopsy study of the extracranial and intracranial cerebral arteries in 100 subjects with a cerebral infarct, and in a control series of 53 cases.

The brain was removed from the skull. The neck vessels, including the aortic arch were removed in one specimen including the cervical spine, the base of the skull, and the soft tissues. The brain and the neck specimen were submitted to post mortem angiography using a barium and saline suspension. The specimens were then fixed with the arteries perfused at 100 mm Hg pressure. The arteries were dissected and examined histologically.

In the 100 cases with a cerebral infarct, eight of the series revealed occlusion of a cerebral artery in the absence of infarction in its territory of supply. In a

to the proximal middle cerebral artery In one subject the infarct was limited to the basal ganglia and the post mortem angiogram (Fig 2) revealed good filling of the territory of the middle cerebral artery via the leptomeningeal anastomoses In the second case the infarct was limited to the temporal lobe adjacent to the Sylvian fissure while in a third case with occlusion of the proximal middle and posterior cerebral arteries, the infarction was limited to the lateral surface of the occipital lobe

The results of this post mortem investigation suggest that the leptomeningeal anastomoses as well as the circle of Willis are often important in the delineation of an area of infarction What may be even more important is that occlusion may occur in a major cerebral artery without ischaemia in its area of supply Baker et coll (1963) suggested that severe occlusive disease of the cerebral arteries occurred to an equal degree in vessels supplying viable brain as in association with a cerebral infarct However, in 1965 Moossy in 142 patients with recent cerebral infarcts, found only three arteries occluded in the absence of cerebral infarction The present study suggests that occlusion of an intracranial cerebral artery may be more common than this and in those cases without evidence of an infarct the leptomeningeal anastomoses play a vital role

SUMMARY

The extra and intra cranial cerebral arteries were examined in 100 cases of cerebral infarction and in 53 cases in a control series Attention is drawn to the frequency with which occlusion of an intracranial cerebral artery occurs without infarction in its area of supply and the importance of the leptomeningeal anastomoses in these cases is discussed Further cases show the effectiveness of these anastomoses in determining the extent of an infarct following occlusion

ZUSAMMENFASSUNG

Die extra und intra kraniellen Gehirnarterien wurden in 100 Fallen mit Cerebralinfarkt und in 53 Kontrollfallen untersucht Die Frequenz womit Okklusion einer intrakraniellen Gehirnarterie ohne das Auftreten eines Infarktes vorkommen kann wird betont Der besondere Wert der leptomeningealen Anastomosen in diesen Fallen wird diskutiert und es wird auf die Wirkung der Anastomosen bei der Ausbreitung des Infarktes infolge einer Okklusion auf Basis weiterer Fallen hingewiesen

RÉSUMÉ

Les auteurs ont examine les arteres cérébrales extra et intra-craniennes dans 100 cas de ramollissement cérebral et dans 53 cas témoins Les auteurs examinent la fréquence de l obstruction d une artere cérébrale intra-cranienne sans ramollissement dans son territoire et etudient l importance des anastomoses leptoméningees dans ces cas D autres cas ont montré l utilité de ces anastomoses pour determiner l étendue d un ramollissement consecutif à une obstruction arterielle

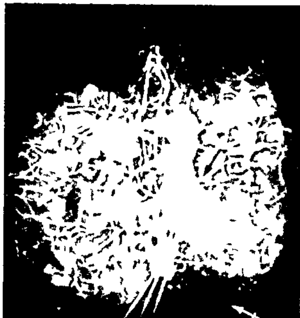


Fig 1 Post mortem angiogram Occlusion of left posterior cerebral artery (↑) with filling of its area of supply via the leptomeningeal anastomoses (↔) infarct limited to the basal ganglia



Fig 2 Post mortem angiogram Occlusion of left middle cerebral artery (↑) with filling of its area of supply via the leptomeningeal anastomoses (↔) infarct limited to the basal ganglia

with occlusion distal to the circle of Willis, only one had severe extracranial cerebral artery disease Hypertension was present in three cases, and a myocardial infarct in two cases In the two cases with occlusions involving the circle of Willis, extracranial artery disease was not present, and hypertension was present in two cases

In the two cases with symptoms but with no infarct, internal carotid occlusion was present in one case, and severe rheumatic heart disease in the second case

The findings in the control series are summarized in Table 2 In the case of bilateral posterior cerebral artery occlusion, unilateral carotid stenosis was the only relevant finding In the three cases with occlusion within the circle of Willis, extracranial artery disease was present in one case, hypertension in three cases, and a myocardial infarct in one case

The findings in a subject with occlusion of the left posterior cerebral artery, but with an infarct confined to the basal ganglia are demonstrated in Fig 1 The angiogram shows good filling of the territory of supply of the occluded artery via the leptomeningeal anastomoses

To further illustrate the effectiveness of the leptomeningeal anastomoses three cases were chosen from the infarct series In two cases the occlusion was limited

to the proximal middle cerebral artery In one subject the infarct was limited to the basal ganglia and the post mortem angiogram (Fig 2) revealed good filling of the territory of the middle cerebral artery via the leptomeningeal anastomoses In the second case the infarct was limited to the temporal lobe adjacent to the Sylvian fissure, while in a third case with occlusion of the proximal middle and posterior cerebral arteries the infarction was limited to the lateral surface of the occipital lobe

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The extra and intracranial cerebral arteries were examined in 100 cases of cerebral infarction and in 53 cases in a control series Attention is drawn to the frequency with which occlusion of an intracranial cerebral artery occurs without infarction in its area of supply and the importance of the leptomeningeal anastomoses in these cases is discussed Further cases show the effectiveness of these anastomoses in determining the extent of an infarct following occlusion

ZUSAMMENFASSUNG

Die extra und intra kraniellen Gehirnarterien wurden in 100 Fallen mit Cerebralinfarkt und in 53 Kontrollfallen untersucht Die Frequenz womit Okklusion einer intrakraniellen Gehirnarterie ohne das Auftreten eines Infarktes vorkommen kann wird betont Der besondere Wert der leptomeningealen Anastomosen in diesen Fallen wird diskutiert und es wird auf die Wirkung der Anastomosen bei der Ausbreitung des Infarktes infolge einer Okklusion auf Basis weiterer Fallen hingewiesen

RÉSUMÉ

Les auteurs ont examiné les artères cérébrales extra et intra craniennes dans 100 cas de ramollissement cérébral et dans 53 cas temoins Les auteurs examinent la fréquence de l obstruction d une artère cerebrale intra-cranienne sans ramollissement dans son territoire et étudient l importance des anastomoses leptoméningées dans ces cas D autres cas ont montré l utilité de ces anastomoses pour determiner l étendue d un ramollissement consecutif à une obstruction artérielle

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FROM THE DEPARTMENTS OF NEURORADIOLOGY (DIRECTOR PROF T GREITZ) AND NEUROSURGERY (DIRECTOR PROF LARS LEKSELL), KAROLINSKA SJUKHUSET, STOCKHOLM SWEDEN

TIME RELATIONSHIP BETWEEN SUBARACHNOID HAEMORRHAGE, ARTERIAL SPASM, CHANGES IN CEREBRAL CIRCULATION AND POSTHAEMORRHAGIC HYDROCEPHALUS

by

ULF BERGVALL and RAFAEL GALERA

For enabling a choice of treatment in cases of intracranial arterial aneurysm rupture and its sequelae increasing demands are being raised with respect to the radiographic information The significance of factors such as cerebrovascular spasm variations in the cerebral circulation and posthaemorrhagic hydrocephalus has consequently received considerable attention These factors were the main objects of the investigations described in the present paper

Material and Method Data from 136 examinations by rapid serial carotid angiography of 70 cases of intracranial arterial aneurysm with one or several episodes of subarachnoid haemorrhage have been analysed Repeat examinations of one and the same hemisphere usually the side of the aneurysm had been made in 42 cases and only the data from that side have been considered The age of the patients at the time of bleeding ranged from 19 to 69 years nearly 80 % being forty

Furthermore a group of 35 cases, in which the size of the lateral ventricle had



Fig 1 Concept of the lateral ventricle from the appearances of the deep cerebral veins Measuring points in a p projections are indicated

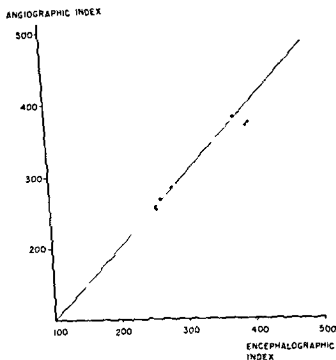


Fig 2 Correlation of estimates of lateral ventricle size (index values) at angiography and encephalography

been angiographically determined were available for comparison with encephalographic findings The mean interval between angiography and encephalography was less than 7 days In roughly half the number of these cases the ventricular system was dilated but in none of them was there evidence of any recent change in ventricular size at the time of examination Nearly 45 % of the patients in this reference material were over 40 years of age

The internal cerebral vein and its tributaries which outline part of the lateral ventricle were chosen as a basis for the determination of the ventricular size The width of the lateral ventricle was considered appropriate, and the most convenient of approach for the numerical expression of the ventricular size It was measured in the a p projection and represented by the distance from the most lateral tributary of the thalamostriate vein perpendicularly to a sagittal plane tangential to the medial border of the internal cerebral vein

The width of the lateral ventricle at encephalography is usually related to the breadth of the corresponding half of the skull The quotient is referred to as the

hydrocephalic index and has been stated to be normally about one third, or less (LINDGREN 1951) A corresponding index calculation may be arrived at from measurements at angiography (Fig 1)

The correlation of index values determined at angiography and encephalography in the reference cases is presented in Fig 2 The measurement chosen to represent the width of the lateral ventricle at encephalography was not the greatest width of the frontal horn, as is often the case, but the width farther back, *nearer the cella media, in order to locate the planes of measurement* at the respective encephalographic and angiographic investigations to approximately the same region of the lateral ventricle This proved to give the best correlation, as was to be expected when considering the usual course of the thalamostriate vein Subtle changes in the appearance of the central cerebral veins may be of diagnostic value as early signs of ventricular dilatation but cannot be used in a systematic study, in which numerical expressions should be found

The diameter of the internal carotid artery was measured at the siphon about 1 cm proximal to the bifurcation, it was noted whether peripheral spasm was present or not

The circulation time was determined as the time from maximum contrast filling of the carotid siphon to maximum filling of the parietal veins (GREITZ 1956 1968) Cerebral blood flow determinations were made with the ^{133}Xe technique described by INGVAR & LASSEN (1961)

Results and Discussion

The time relationships between the latest bleeding, the diameter of the carotid siphon, and circulation time variations, are illustrated in Fig 3 *It may* be observed that in both diagrams there is an accumulation of abnormal values to the second as well as to the third week after bleeding, in line with the observation of KAGSTROM et coll (1965) that cerebrovascular spasm is most marked six to twelve days after a subarachnoid haemorrhage Exceptions in the present material to this general pattern during the first 6 day period after bleeding are cases with intracerebral haematoma, or one or more recent subarachnoid haemorrhages before the last bleeding, in the diagram being represented at origo The early appearance of spasm in cases of intracerebral haematoma has also been reported by KAGSTROM, POOL & POTTS (1965), and by others The role of the mechanical factors contributing to cerebrovascular spasm in such instances has been discussed by JOHNSON et coll (1958)

Seven cases were found to have a relatively narrow carotid siphon six weeks to six months after bleeding (Fig 3) Six of these were found to have or to have

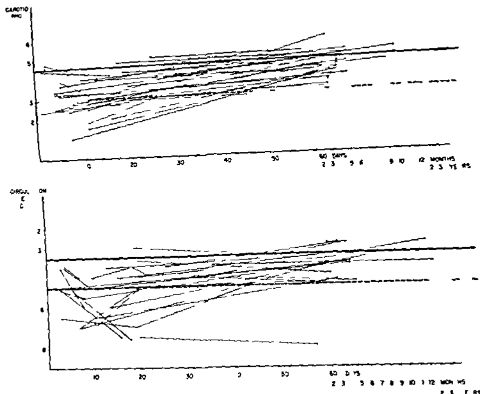


Fig 3 Time relationship between the last subarachnoid haemorrhage carotid siphon diameter and circulation time Full horizontal lines mean normal values broken horizontal lines the 3 S D range The repeat homolateral examinat on values are connected the circulation time value are assigned to an inverted scale

developed ventricular dilatation GREITZ has reported subnormal cerebral blood flow values also in non pressure hydrocephalus A narrow carotid siphon such a long time after bleeding may be interpreted as an adaptation of the arterial system to reduced flow in conjunction with posthaemorrhagic hydrocephalus Among other possibly contributing factors a shrinkage process around the vessel following massive haemorrhage may be considered (JOHNSON et coll)

The case which — two months after bleeding — had the most prolonged circulation time had also the largest lateral ventricle measured in the material (Figs 3 and 6)

The same general pattern as in Fig 3 regarding the appearance of central as well as peripheral spasm and prolonged circulation time is still seen if cases with multiple haemorrhages are excluded (Fig 4)

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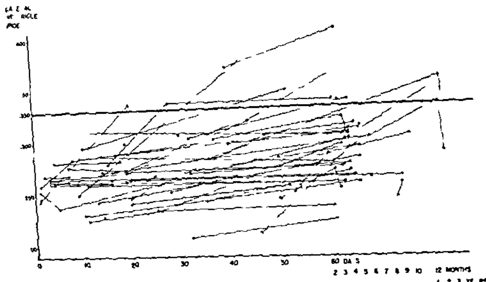


Fig 6 Development of posthaemorrhage hydrocephalus after the first subarachnoid haemorrhage Full horizontal line at index level 0 33 The repeat homolateral examination values are connected

Determinations of the cerebral blood flow in the present material were too few to warrant definite conclusions Low values were noted in the period after bleeding when spasm occurred and the circulation time was prolonged (Fig 5) The two small inset diagrams show that in these cases the correlation appears weaker between the values on the carotid siphon diameter and the cerebral blood flow than between the carotid siphon diameter and the circulation time

The development pattern of posthaemorrhagic hydrocephalus is presented in Fig 6 in which the angiographic estimates of the lateral ventricle width are plotted as index values index 0 33 indicating an arbitrary upper normal level Sixty three out of seventy cases could be measured a third of these had multiple haemorrhages and are plotted from the first bleeding episode

Considering the estimated error of measurement index changes exceeding 0 025 (corresponding to 2 mm difference measured in the film) have been stated to represent a true change in ventricular size There was a definite, in most cases considerable increase in ventricular size in nineteen out of the forty two cases controlled with repeat examinations Two more cases single examinations at 3 and 10 months respectively after bleeding had ventricular dilatation above index level 0 33 making a total of twenty-one cases or 33 %, of all measured cases found to have or to have developed ventricular dilatation This figure

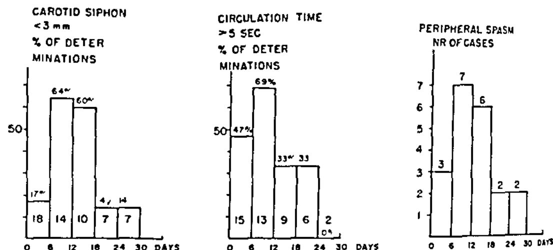


Fig 1 Frequency of carotid siphon narrowing circulation time prolongation and peripheral spasm during the five first 6 day periods after subarachnoid haemorrhage cases with multiple haemorrhages being excluded Figures within columns indicate total number of determinations.

Fig 5 Main diagram represents cerebral blood flow determinations Full horizontal line mean normal value broken line the 2 S D range Small diagrams above same cases

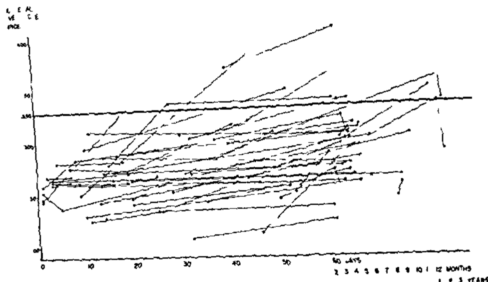


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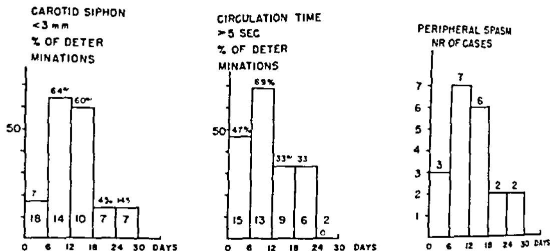


Fig 4 Frequency of carotid siphon narrowing circulation time prolongation and peripheral spasm during the five first 6 day periods after subarachnoid haemorrhage cases with multiple haemorrhages being excluded Figures within columns indicate total number of determinations

CEREBRAL
BLOOD FLOW
ML 100G/MIN

60
50
40
30
20

0 10 20 30 40 50 60 DAYS
2 3 MONTHS

Fig 5 Main diagram represents cerebral blood flow determinations Full horizontal line mean normal value broken line the 2 S D range Small diagrams above same cases

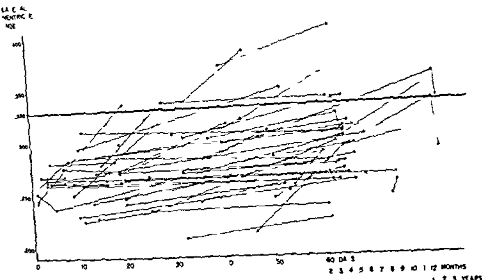


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is higher than that suggested by others (THEANDER et coll 1967, CRONQVIST 1967) Ventricular dilatation has not been observed to develop earlier than 20 days after bleeding and appears usually to start later and to develop during a longer period of time

The reason for choosing the index change 0 025 as the limit corresponding to a true change in ventricular size could be discussed Problems in connection with measurements of the deep cerebral veins have been dealt with extensively by JOHANSSON (1954), and from a study of his work the figure 0 025 was considered reasonable However, the tendency in the present material towards ventricular dilatation is marked, and an extension of the index change limit to 0 03 (= 2 5 mm) or 0 04 (= 3 2 mm) would still render a number of cases with ventricular dilatation corresponding to as much as 29 % and 22 %, respectively These figures, by a consideration of the diagram in Fig 6, would seem to be too low

Two cases developed hydrocephalus within 20 and 28 days of bleeding both with a prolonged circulation time and severe spasm Intracerebral haematomas were found more frequently in cases developing ventricular dilatation

Twenty three of the forty two cases that have been followed are considered to be unchanged Five of these are, however, difficult to evaluate because of the short observation time

A definite lowering of the index was evident in only one case This appears to be explained by the introduction of an atrioventricular shunt between the last two examinations (Fig 6)

The possible influence of operative trauma upon the development of ventricular dilatation cannot be assessed in detail in the present material The cases in which this possibility cannot be excluded as a major contributing factor amount however to only six out of the twenty one dilated cases

The high incidence of ventricular dilatation in the material is partly a matter of definition, as repeat examinations in a number of cases disclosed a considerable increase in ventricular size though not of a magnitude to be recognized as such at single examinations The possibility of uncovering a developing post haemorrhagic hydrocephalus at repeat examinations by carotid angiography often performed for other reasons after subarachnoid haemorrhage, should be kept in mind

SUMMARY

A material of angiographic examinations following subarachnoid haemorrhage from aneurysm rupture was reviewed Spasm appeared to be most frequent and intense during the second and third weeks and tended to disappear in most of the cases after four to

five weeks Prolon ation of the circulation time seemed to follow a similar pattern Post haemorrhagic ventricular dilatation is a frequent complication the incidence in the material being 33 per cent

ZUSAMMENFASSUNG

Ein Material von an iographis hen Untersuchungen in Fällen von Subarachnoidalblutung die durch Ruptur eines Aneurysmas verursacht war wurde wied rpruft Spa men der Ge fa se schienen am haufigsten und am stark ten wahrend der zweiten und dritten Wo he auf zutreten und nei ten meistens nach vier bis funf Wochen zu verschwinden Die Verzog rung der Blutumlaufzeit verhielt sich in ahnlicher Wei e Po thamorrhagische Ventrikeldilatation i t eine haufig auftretende Komplikation bei diesem Material trat sie in 33 % der Falle auf

RÉSUMÉ

Les auteurs ont passé en revue une série d angiographies apres hemorragie sous arachnoidienne par rupture d anevrysme C est pendant les deuxieme et troisieme semaines que le pasme arteriel est le plus fréquent et le plus intense il tend a disparaitre dans la plupart des cas au bout de 4 ou 5 semaines La prolongation du temps de circulation cérébral parait suivre une evolution semblable La dilatation ventriculaire post hemorragique e t une complication frequente sa fréquence dans cette serie est d 33 %

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FROM THE ROENTGEN DEPARTMENT OF THE INSTITUTE OF NEUROSURGERY (DIRECTOR PROF. A. ASENJO), SANTIAGO, CHILE

CEREBRAL ANGIOGRAPHY IN TRAUMATIC SWELLING OF THE TEMPORAL LOBE

by

MARIO CASTRO

The clinical signs in trauma of the skull are not always so definite and precise as to indicate a correct treatment. Cerebral angiography would therefore appear to be the only method that provides full information on the true condition of the brain following injury. The radiologic diagnosis of cerebral contusion has been centered mainly on the problem of laceration.

The purpose of this investigation was to establish the morphologic basis for a differentiation between various degrees of injury to the temporal lobe. A study of 155 cases of traumatic swelling of the temporal lobe, 58 of which were confirmed surgically, permitted a distinction to be made between oedema, mild contusion, severe contusion and laceration.

The common signs in all these lesions are elevation of the Sylvian vessels in lateral projections and deformity due to compression of the lateral ventricle in the a.p. phlebogram. Lateral displacement of the pericallosal artery and the central veins may be absent. The vessels may often lie in the midline, especially in lesions involving the temporal lobe alone. The distinction between different degrees of expansivity of traumatic lesions of the temporal lobe may be reached by studying the type of elevation of the Sylvian vessels in the lateral view.

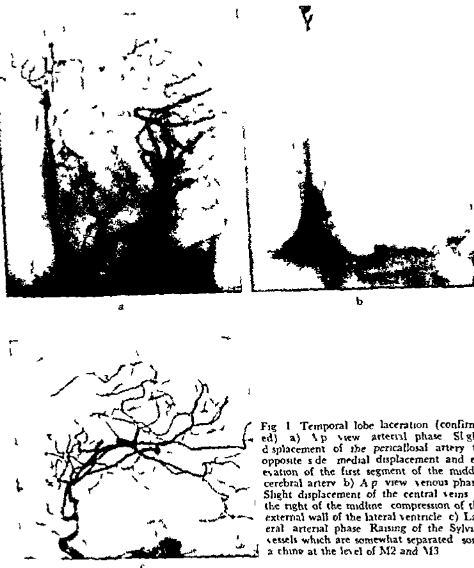


Fig 1 Temporal lobe laceration (confirmed) a) A p view arterial phase Slight displacement of the pericallosal artery to opposite side medial displacement and elevation of the first segment of the middle cerebral artery b) A p view venous phase Slight displacement of the central veins to the right of the midline compression of the external wall of the lateral ventricle c) Lateral arterial phase Raising of the Sylvian vessels which are somewhat separated some a thing at the level of M2 and M3

Temporal lobe laceration This has already been studied by COLUMELLA and others It is the result of severe injury and varies from small scattered foci up to a massive involvement of the lobe The lesion consists of a mixture of crushed cerebral tissue and blood and may sometimes erroneously be taken for an intra cerebral hematoma Temporal lobe laceration may produce slight displacement

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The common signs in all these lesions are elevation of the Sylvian vessels in lateral projections and deformity due to compression of the lateral ventricle in the a p phlebogram Lateral displacement of the pericallosal artery and the central veins may be absent The vessels may often lie in the midline, especially in lesions involving the temporal lobe alone The distinction between different degrees of expansivity of traumatic lesions of the temporal lobe may be reached by studying the type of elevation of the Sylvian vessels in the lateral view

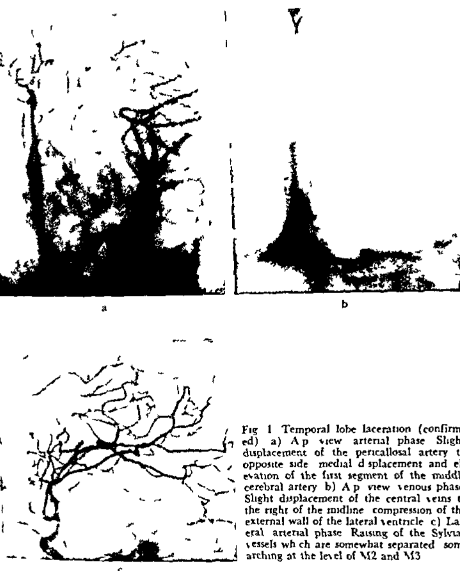


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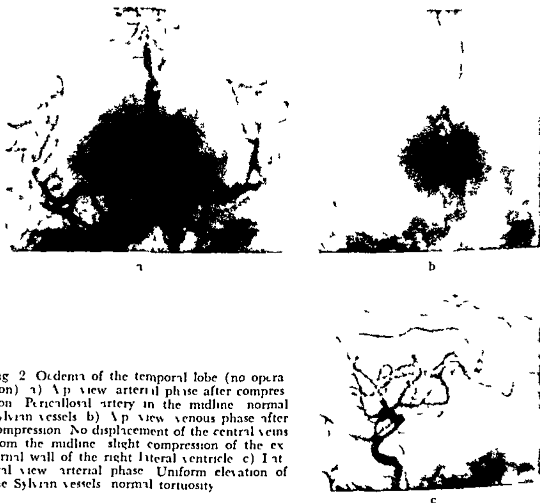


Fig 2 Oedema of the temporal lobe (no operation) a) A p view arterial phase after compression Pericallosal artery in the midline normal Sylvian vessels b) A p view venous phase after compression No displacement of the central veins from the midline slight compression of the external wall of the right lateral ventricle c) Lateral view arterial phase Uniform elevation of the Sylvian vessels normal tortuosity

of the midline structures to the opposite side in the a p angiogram There may also be raising of the first segment of the middle cerebral artery and stretching and medial displacement of the M2 segment of this vessel (Fig 1a) The central veins may be displaced and the lateral ventricle may appear compressed because of displacement of the thalamostriate vein (Fig 1b)

The lateral projection in temporal lobe laceration usually reveals raising of the Sylvian vessels the latter appear slightly arched and separated but retain some tortuosity (Fig 1c) The explanation is that the vessels are surrounded by lacerated tissue In intracerebral hematomas, on the other hand, the arteries are definitely arched and are displaced uniformly as well as stretched The expanding lesion is located under the vessels

Oedema of the temporal lobe is the mildest form of cerebral contusion This often causes disturbances, the nature of which can be accurately diagnosed only



Fig 3 Severe contusion of the temporal lobe (confirmed) a) A p view arterial phase Contra lateral displacement of the pericallosal artery stretching and raising of the first segment of the middle cerebral artery rigidity of the M2 and M3 segments b) Lateral view arterial phase Elevation and separation slight arching of the Sylvian vessels



Fig 4 Mild contusion of the temporal lobe a) A p view arterial phase Stretching of the pericallosal artery without contralateral displacement *of the first* segment of the middle cerebral artery b) Lateral view arterial phase Elevation of the Sylvian vessels

by cerebral angiography The angiographic appearances are characterized by a uniform elevation of the Sylvian vessels which are not compressed but follow a normal trajectory There may be slight rigidity of the M2 segment of the middle cerebral artery and slight compression of the lateral ventricle (Fig 2)



Fig 5 Severe contusion of the temporal lobe a) Lateral view arterial phase Uniform elevation of the Sylvian vessels with some arching of the first part of the gyrus angularis artery (hematoma underneath) b) Lateral view venous phase Raising of the Sylvian veins indicating swelling of the temporal lobe

The majority of the cases, with areas of contused brain tissue surrounded by oedema, lies between these two groups

Severe contusion of the temporal lobe produces angiographic appearances similar to those observed in laceration There is raising of the Sylvain vessels and their separation is more marked (Fig 3), this indicates the existence of normal areas of the brain alternating with severely contused regions It is usually possible to detect the presence of small or medium sized hemorrhagic foci (Fig 4) In a somewhat milder form of swelling of the temporal lobe due to contusion the arteries are lifted en bloc They appear even more normal than in severe contusion but a slight degree of separation may be evident (Fig 5) Not all cases of severe and minor degrees of contusion of the temporal lobe become surgical for, according to their evolution, a correct differential diagnosis by cerebral angiography may avoid a brain tissue resection Temporal lobe resections often result in epilepsy, and should, if possible, be withheld

Conclusions

Carotid angiography makes it possible to obtain an accurate diagnosis in temporal lobe contusion Four degrees of temporal lobe contusion, according to its severity, may be distinguished A precise diagnosis results in more conservative treatment and decreases temporal lobe resections

SUMMARY

Temporal lobe swelling due to traumatic contusion is discussed in reference to a material of 155 cases examined by angiography The value of the procedure is stressed and the differential diagnosis considered

ZUSAMMENFASSUNG

Angiographie wurde in 155 Fällen von Ödem des Schlafenlappens nach traumatischer Kontusion des Schadels vorgenommen Der Wert dieser Untersuchungsmethode und die Differenzialdiagnose werden besprochen

RÉSUMÉ

L'auteur se basant sur 155 cas examinés par angiographie étudie l'augmentation de volume du lobe temporal due a la contusion traumatique Il souligne l'interet de cette methode et examine le diagnostic differentiel

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Fig 5 Severe contusion of the temporal lobe a) Lateral view arterial phase Uniform elevation of the Sylvian vessels with some arching of the first part of the gyrus angularis artery (hematoma underneath) b) Lateral view venous phase Raising of the Sylvian veins indicating swelling of the temporal lobe

The majority of the cases, with areas of contused brain tissue surrounded by oedema, lies between these two groups

Severe contusion of the temporal lobe produces angiographic appearances similar to those observed in laceration There is raising of the Sylvian vessels and their separation is more marked (Fig 3), this indicates the existence of normal areas of the brain alternating with severely contused regions It is usually possible to detect the presence of small or medium sized hemorrhagic foci (Fig 4) In a somewhat milder form of swelling of the temporal lobe due to contusion the arteries are lifted en bloc They appear even more normal than in severe contusion but a slight degree of separation may be evident (Fig 5) Not all cases of severe and minor degrees of contusion of the temporal lobe become surgical for, according to their evolution, a correct differential diagnosis by cerebral angiography may avoid a brain tissue resection Temporal lobe resections often result in epilepsy, and should, if possible, be withheld

Conclusions

Carotid angiography makes it possible to obtain an accurate diagnosis in temporal lobe contusion Four degrees of temporal lobe contusion, according to its severity, may be distinguished A precise diagnosis results in more conservative treatment and decreases temporal lobe resections

SUMMARY

Temporal lobe swelling due to traumatic contusion is discussed in reference to a material of 155 cases examined by angiography The value of the procedure is stressed and the differential diagnosis considered

ZUSAMMENFASSUNG

Angiographie wurde in 155 Fallen von Ödem des Schlafenlappens nach traumatischer Kontusion des Schadels vorgenommen Der Wert dieser Untersuchungsmethode und die Differenzialdiagnose werden besprochen

RÉSUMÉ

L auteur se basant sur 155 cas examines par angiographie etudie l augmentation de volume du lobe temporal due a la contusion traumatique Il souligne l intéret de cette methode et examine le diagnostic differentiel

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FROM THE DEPARTMENT OF RADIOLOGY (PROF JOHN A EVANS), CORNELL UNIVERSITY MEDICAL COLLEGE AND THE NEW YORK HOSPITAL, AND ST LUKE'S HOSPITAL CENTER (DIRECTOR NATHANIEL FINBY), NEW YORK, USA

TRANSFEMORAL CAROTID AND VERTEBRAL ANGIOGRAPHY

by

KUO YORK CHYNN

In studies of the intra and extra cranial vasculature, the transfemoral approach (PEIRCE 1951, LINDGREN 1956, ÖDMAN 1956, GENSINI & ECKER 1960, CRONQVIST 1961, WESTCOTT, CHYNN & STEINBERG 1963, MILNE 1964), in contrast to transbrachial and transaxillary angiography, has received surprisingly little attention

This paper is based on the results of 311 transfemoral angiographic examinations in 202 patients performed by the author at the New York Hospital, Cornell Medical Center (see Table 1) The transfemoral approach was attempted in 210 consecutive cases and failed in eight The rate of success was thus 96 % Thirty nine of the 202 patients were above the age of sixty

From the experiences gained in this series the following indications for the transfemoral approach are recommended

1 When a preliminary examination of the aortic arch is desirable if no lesion is found in the brachiocephalic arteries the arch catheter will be replaced by a proper catheter for selective carotid or vertebral angiography

2 When vertebral angiography alone, or in addition to carotid angiography, is required

3 When direct carotid puncture for various reasons should be avoided, as

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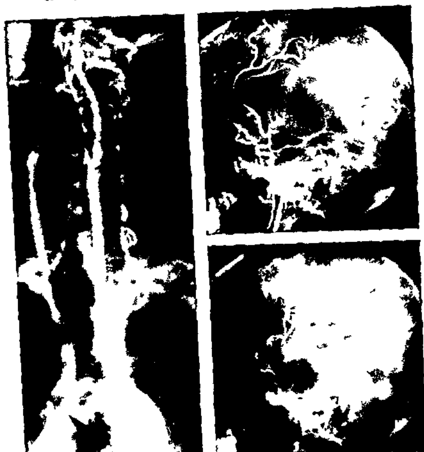


Fig 1 The transfemoral a ch ane ogram (left) reveals normal extracranial *carotid* and vertebral arteries For selective left carotid angiography (iews above) the arch catheter (arrow n left view) was replaced by an *s-shaped catheter* These angiograms reveal occlusion of the middl cerebral artery and retrograde fill ng of the middle cerebral arteries in the capillary phase

when a ubintimal injection has resulted from a direct puncture of the carotid artery when puncture has been unsuccessful and when the contralateral carotid artery is o cluded

The success of transfemoral catheterization depends mainly on two factors the pre designed shape of the catheter tip and skillful manipulation of the cath eter and wire We use yellow or red Ödman catheters and Seldinger guide wire (SELDINGER 1953) Two basic shapes for the catheter (Figs 4 and 5) enabled us to perform carotid and vertebral angiography in almost all our pa tients The choice of catheter depends on the patient s age and the appearance



Fig 2 (In this case a subintimal injection into the right carotid artery led to the misdiagnosis of carotid occlusion and intracranial angiography was unsuccessful) One day later transfemoral catheterization with progress spot films revealed patency of the entire right carotid artery

of the aortic arch in p a and lateral chest films A gentle turn of the catheter, a few degrees at a time, ensures much better control of the catheter than a rapid push and pull

Sixty transfemoral *vertebral* angiographic examinations (Table 1) were carried out If the vertebral artery was of sufficient size, the tapered tip of a red Ödman catheter (outer diameter 2 2 mm) could be introduced into the artery Test injections are routinely made under image intensification to assess the size of the vertebral artery and the free flow of the contrast medium, both before and after introduction of the catheter into the artery A vertebral angiogram of good diagnostic quality may often be obtained merely by placing the distal end of the yellow Ödman catheter in the subclavian artery, as illustrated in Fig 3

Sixty eight right and ninety two left *carotid* angiographic examinations were made Two basic maneuvers have facilitated the catheterization of the right and left carotid arteries

Table 1

Transfemoral angiography in 311 examinations of 202 patients aged between 7 and 79 years

Aortic arch and left carotid artery	32	Left carotid and vertebral artery	8
Aortic arch and right carotid artery	13	Bilateral carotid and vertebral artery	11
Aortic arch and vertebral artery	6	Bilateral carotid	18
Aortic arch	40	Right carotid artery	68
Vertebral artery	25	Left carotid artery	92
Right carotid artery	18	Vertebral artery	60
Left carotid artery	21	Aortic arch	91
Right carotid and vertebral artery	10		

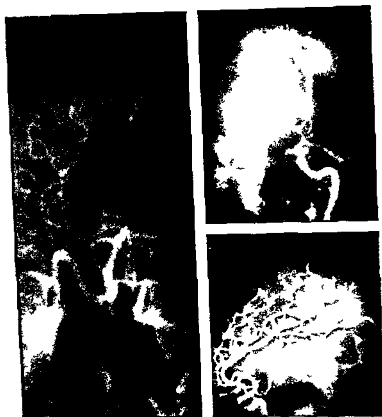


Fig 3 Case of subarachnoid hemorrhage Transfemoral bilateral carotid angiography and left vertebral angiography at one sitting revealed a large space-occupying mass in the right temporal region (At surgery a large intracerebral hematoma was found due to a small arteriovenous anomaly)

Maneuver I (for young patients with ordinary aortic arch Fig 4)

1 The preshaped catheter tip is introduced into the innominate artery (or the left common carotid) (Fig 4a) A mere upward advance of the catheter will bring it back into the arch (arrow)

2 We introduce a guide wire with a 3 cm long soft tip (Fig 4b) The stiff part of the wire (arrows) then straightens out the curved catheter

3 It then allows passage of both the wire and the catheter up to the bifurcation (Fig 4c)

4 Finally the wire is withdrawn and the catheter is in place (Fig 4d)

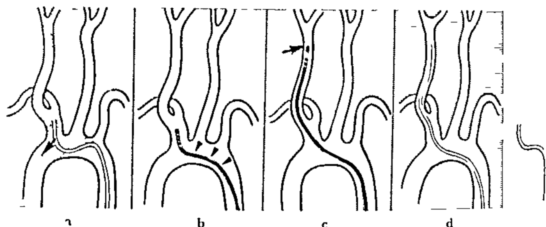


Fig 4 Diagram of maneuver I for obtaining selective right and left carotid angiograms used in young patients with ordinary aortic arch

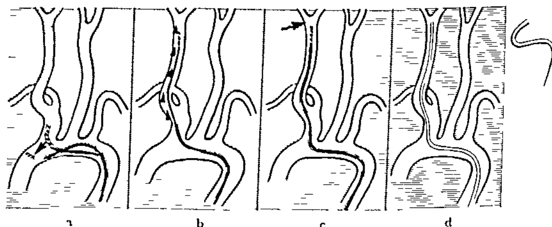


Fig 5 Diagram of maneuver II for obtaining selective right and left carotid angiograms used in older patients with tortuous and elongated aortic arch

Maneuver II (for older patients with tortuous and elongated aortic arch Fig 5)

1 The catheter, even with the wire inserted into it, will be deflected into the arch (Fig 5a, arrow)

2 The maneuver, while holding the catheter tightly with one hand aims at bringing the wire out of the catheter up to the bifurcation (Fig 5b, arrows)

3 Then, while holding the wire tightly with one hand, the catheter is thread along the wire up to the bifurcation (Fig 5c, arrow)

4 Finally, the wire is withdrawn, and the catheter is in place (Fig 5d)

Table 2

Fatal complications in cerebral angiography in different materials

	Period	Number of patients	Deaths	Death rate
Author s material	June 1960/Feb 1967	436	2	0 4
ABBOTT et coll	1952	150	5	3 3
CODDON & KRIEGER	1958	483	8	1 6
FEILD et coll	1962	2000	8	0 4

Table 3

Comparison of non fatal neurologic complications in different materials

	Period	Number of patients	Transient	Permanent
Autho s material	Jan 1965/Oct 1966	133	6 (4 5)	0
FEILD t coll	1962	2000	33 (1 6)	8 (0 4)
CODDON & KRIEGER	1958	483	44 (9 1)	57 (11)
CHASE & KRICHEFF	1965	474	11 (2 3)	3 (0 6)
ALLEN et coll	1965	400	13 (3 2)	1 (0 25)

Complications The charts of 436 patients studied transfemorally for neurologic problems were reviewed and compared to statements in the literature (Table 2) Two deaths in one series could be attributed to the angiographic procedure For an evaluation of the non fatal neurologic complications 133 patients were studied Transient complications occurred in 4 5 % and there were no permanent complications These results were also compared with series from the literature (Table 3)

Conclusion

The advantages of the transfemoral catheterization technique are in our opinion that it permits a preliminary study of the aortic arch for all the brachiocephalic branches and that puncture and trauma to the vital carotid and vertebral arteries can be avoided A bilateral study of the carotid and the vertebral arteries can be made at one examination The quality of the films obtained is as good as with direct puncture and it is superior to and more selective than films obtained from brachial angiography No subintimal injections have occurred and the success rate has been high i e 96 %

SUMMARY

A series of 311 transfemoral angiographic examinations performed by the author in 207 patients with neurologic diseases was reviewed. Four major indications for the transfemoral approach are given and two specific maneuvers to achieve selective right and left carotid catheterization are described. The advantages of the transfemoral technique are enumerated.

ZUSAMMENFASSUNG

Der Verfasser hat 311 transfemorale angiographische Untersuchungen in 207 Patienten mit neurologischen Krankheiten durchgeführt und dieses Material wird analysiert. Vier hauptsächliche Indikationen für die transfemorale Technik werden angegeben und zwei spezifische Manöver um selektive Katheterisierung der linken und rechten A. carotis durchzuführen werden beschrieben. Die bei der transfemoralen Katheterisierungstechnik erbotenen Vorteile werden angeführt.

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR PROF OLLE OLSSON)
THE UNIVERSITY HOSPITAL LUND SWEDEN

VENOUS ABNORMALITIES IN CEREBROVASCULAR DISORDERS

by

S CRONQVIST and F LAROCHE

A combined study of angiography and cerebral blood flow measurements in patients with cerebral lesions of various kinds has revealed important relations between the changes observed with the two techniques Thus it has been demonstrated that focal blood flow changes may occur in the regions involved in the presence both of tumours and cerebrovascular lesions The observation that *even local* hyperaemia may be present in cases of vascular lesions was considered of particular importance It was noted that such a change in blood flow corresponds to the angiographic demonstration of a contrast blush or an abnormal passage of contrast medium to the cerebral veins manifest as an early filling of one or more veins within or close to the region with lesion (CRONQVIST & LAROCHE 1967)

Preliminary observations were based upon a limited number of cases Continued experiences produced the impression that *the changes* i e contrast blush and early venous filling actually were frequently occurring signs of a vascular lesion even in cases having minor local circulatory disturbances Since the recognition of these angiographic changes would *obviously* be of diagnostic value an investigation was made into the contrast filling of veins in different regions The occurrence of focal abnormalities in the capillary phase was also studied

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Table 1

Data on the start of contrast filling of different veins in relation to the filling of the parietal veins (PV) obtained in 53 angiographic examinations of 42 cases — Figures indicate number of cases

	Seconds earlier than PV							PV	Seconds later than PV					
	3 5	3 0	2 5	2 0	1 5	1 0	0 5	0	0 5	1 0	1 5	2 0	2 5	3 0
Normal cases														
Frontal veins						2	15	15						
Parietal veins								32						
Middle cerebral veins						2	6	21	3					
Basal vein							2	17	10	1	1	1		
Internal cerebral vein								17	12	2		1		
Pathologic cases														
Frontal veins					3	5	16	26	2	1				
Parietal veins								53						
Middle cerebral veins				1	3	7	26	15		1				
Basal vein						1	9	6	2	1				
Internal cerebral vein					1	6	17	14	11	2	1	1		

Maximum filling of the carotid siphon was determined in all the examinations in this series and the intervals to the start of filling and to maximum filling of the regional veins were registered The regional veins studied were the parietal frontal middle cerebral basal and internal cerebral veins These were selected because they generally fill well and are easily identified they are thus the most practical to use in routine work

In Tables 1 and 2 the filling of the frontal middle cerebral, basal and internal cerebral veins are related to the filling of the veins in the parietal region as described by GREITZ The tables indicate that in this series of cerebrovascular lesions the regional veins were filled both earlier and later than normal This was the case with all the veins studied but was most frequently noted in the middle cerebral and internal cerebral veins The tendency towards abnormal early filling was more marked and occurred more frequently than late filling The form in which the data are presented in the tables precludes any deduction regarding when early or late filling of the parietal veins occurred such abnormal filling was however also noted in the series There was no difficulty in separating the abnormally filling veins from other veins within the same region

A capillary contrast blush in addition to the venous abnormalities was usually also seen This blush was confined to the same region as the vein and most

Technique Serial angiography was employed A total of 18 films was exposed over about 15 seconds with two exposures per second for the first six seconds The examinations were always performed with a manual injection of the contrast medium (Urografin 60 %) into the internal carotid artery, either after direct puncture or selective catheterization of this artery Seven millilitres of the medium were injected through a catheter, or 6 ml through a needle The examinations were usually made by the same radiologist The injection time lay between one and one and a half seconds To evaluate abnormally early appearance of contrast medium in the regional veins, the mean circulation time, as well as the regional cerebral circulation time, were determined by the Greitz method The results were compared with data available from a normal series (GREITZ 1956)

Material The series included 53 angiographic examinations in 42 cases forty one of which had clinical signs of cerebrovascular disease The age of the patients varied between 8 and 75 years, with five patients below 40 six between 41 and 50 ten between 51 and 60, eighteen between 61 and 70, and three patients between 71 and 75 years of age

Results

GREITZ (1956) in his thesis on the cerebral circulation, investigated the time interval between the maximum filling of the carotid siphon and the beginning of filling of the different regional veins Regional variations were noted but he found that the parietal region may be regarded as a representative area for the veins , i e the time when the parietal veins start filling is an average of that of all regional veins Normally, all the regional veins but the frontal veins begin to fill later than the parietal veins On the other hand, frontal veins middle cerebral veins, the vein of Labbe the basal veins and the inferior longitudinal sinus may fill earlier than the parietal veins These veins were however never seen to fill more than one second before the parietal veins GREITZ also studied the difference in time for maximum contrast filling of regional veins in relation to the maximum filling of the parietal veins Maximum concentration was obtained in the same order as the veins started to fill No veins were observed to achieve maximum filling more than one second earlier than the parietal veins

GREITZ used Triurol 50 % (3 acetylamino 2,4,6 tri iodo-benzoate) as contrast medium in his investigation The mean circulation time was 4 13 seconds and the S D ± 0 74 seconds A recent investigation has indicated that the normal circulation time is shortened to between 2 5 and 3 5 seconds with Urografin 60 % (GREITZ, personal communication) There is however no reason to believe that the order of venous filling is in any way changed by the use of this new contrast medium

in several different regions filled early and simultaneously Even abnormally late filling of veins occurred in the region of the haematoma in these cases It was characteristic that the angiographic abnormalities were confined to the periphery of the lesion most often to its posterior aspects

In the group of cases without angiographic signs of occlusive lesions early filling of the veins or capillar blush occurred in twenty nine of forty-one angiographies These two changes did not always appear together There were cases in which the only abnormality was early filling of the veins and others with only a local capillary blush

It should be emphasized that the veins described above are not abnormal in the sense that they are newly formed vessels but are normally occurring veins filling at an abnormal time The passage of contrast medium through the vessels in or close to a vascular lesion may be expected to be slower than normal Actually signs of an increased circulation are instead demonstrated at angiography by early filling of the local capillaries or veins The present study has demonstrated that these changes are not necessarily very marked but that an increased circulation may be manifest as less marked disturbances in the venous circulatory pattern

Conclusion

Cases in which angiographic studies revealed none of the changes generally considered compatible with a haematoma or an occlusion still presented evidence of local circulatory disturbances It was further observed that in cases with definite and characteristic angiographic signs of a vascular lesion the region with these changes and the region with early filling veins or a contrast blush were identical Thus the angiographic appearance of the last mentioned abnormalities not only permits a diagnosis of a cerebrovascular lesion but also makes correct localization possible It was also demonstrated that disturbances in the dynamics of the venous filling frequently occurred and such changes should therefore be taken into consideration in all angiographic studies of patients with a clinical diagnosis of cerebrovascular lesion

SUMMARY

The dynamics of the venous filling was studied in fifty three angiographic examinations representing 4? cases in which 41 had clinical signs of cerebrovascular disease Since such studies are of importance in the diagnosis and localization of cerebrovascular lesions they should be undertaken whenever these conditions are likely to be present

Table 2

Data on the time of maximum filling of different veins in relation to the filling of the parietal veins (PV) obtained in 53 angiographic examinations of 42 cases. — Figures indicate number of cases

	Seconds earlier than PV							PV	Seconds later than PV						
	3.5	3.0	2.5	2.0	1.5	1.0	0.5	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Normal cases															
Frontal veins						3	18	11							
Parietal veins								32							
Middle cerebral veins						7	16	8	1						
Basal vein						1	12	12	3	2	1	1			
Internal cerebral vein							1	2	14	8	6	1			
Pathological cases															
Frontal veins			1			9	19	21	3						
Parietal veins								53							
Middle cerebral veins	1			1	2	9	25	13	2						
Basal vein				1	1	1	7	5	1			1			
Internal cerebral vein	1				1	4	11	22	10	1	1	1			

evident in cases with early filling veins. It was, however, seen also in cases in which there was late filling of veins.

To determine whether abnormally filling veins or a contrast blush are of diagnostic help in localizing a focal vascular lesion the examinations were separated into two main groups, those with and those without the characteristic roentgenologic signs generally associated with a vascular lesion.

The first group consisted of twelve cases with arterial occlusion, in eight of which abnormally early filling of local veins occurred. When the occlusion was confined to the central part of the middle cerebral artery there was early filling of the deep central veins. This also occurred when the occlusion of the middle cerebral artery was peripheral to the arteries supplying the basal ganglia. The last mentioned artery then regularly appeared wider than usual and had a high contrast density. Early filling of mainly superficial veins was observed in cases with occlusion of a peripheral branch of the middle cerebral artery. Abnormal early filling of the regional veins never occurred in cases with an established collateral circulation.

Early filling veins but no contrast blush were seen in intracerebral bleeding, angiographically demonstrated by the presence of an expansivity without concomitant signs of arterial occlusion. The veins involved were generally confined to the region with the expansivity. In one case with an extensive lesion the vein

in several different regions filled early and simultaneously Even abnormally late filling of veins occurred in the region of the haematoma in these cases It was characteristic that the angiographic abnormalities were confined to the periphery of the lesion most often to its posterior aspects

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Normal cases															
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ANATOMICAL AND ANGIOGRAPHIC STUDIES OF ARTERIES SUPPLYING ANTERIOR PART OF TEMPORAL LOBE

A preliminary report

by

L DAHLSTROM G FAGERBERG L LANNER and S STATTIN

A detailed knowledge of the normal vascular anatomy is of great importance in the interpretation of angiograms The vascular anatomy of the middle and posterior parts of the temporal lobe is fairly well known but it appears that the vessels to the most anterior part have been rather neglected in the angiographic literature Arteries to the temporal pole have been described by MONIZ VANDER EECKEN RING and others but no detailed description of the angiographic anatomy of these vessels seems to be available and no systematic investigation of their value in the diagnosis appears to have been made

We have investigated the normal vascular anatomy of the temporal pole in autopsy specimens as well as in clinical angiograms The post mortem study was performed after injection of contrast medium into the internal carotid artery After having obtained roentgenograms in various projections the vessels were dissected free while photographs were taken

The temporal pole was usually supplied by one artery arising from the main stem of the middle cerebral artery or from its first major branch medial or

ZUSAMMENFASSUNG

Die Dynamik der Kontrastfullung der Venen wurde in dreiundfunfzig angiographischen Untersuchungen von 42 Fallen studiert von denen 41 klinische Zeichen cerebrovaskularer Erkrankung aufwiesen Da die dynamischen Stromungsverhaltnisse bei der Diagnose und Lokalisierung einer cerebrovaskularen Lasion von grossem Wert sind sollten diese immer untersucht werden wenn klinische Zeichen auf Gefass Storungen im Gehirn vorliegen

RÉSUMÉ

La dynamique du remplissage veineux est importante pour le diagnostic des lesions cerebrovasculaires et devrait etre étudiée sur tous les examens angiographiques ou de telles lésions sont possibles Le matériel consiste en 53 examens angiographiques, dans 42 cas, dont 41 avaient des signes cliniques d affections vasculaires cérébrales Les auteurs examinent la demarche logique du diagnostic et la localisation des lésions

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Fig 2 Normal angiogram lateral view (subtraction) The anterior border of the middle fossa is marked with a dotted line The horizontal line indicates the level of the floor of the middle fossa The pole arteries (arrows) are of normal appearance



a



b

Fig 3 a) Oblique view of lower and lateral surface of a temporal pole specimen The apex of the pole lies to the left branches of the pole artery cross the gyri and dip down in the sulci b) Lateral roentgenogram of the specimen. In this projection the vessels to the pole (arrow) appear curly

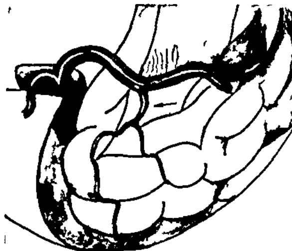


Fig. 1. Schematic drawing of the temporal pole as seen from above. The middle cerebral artery crosses the upper surface of the lobe about 3 cm behind the apex of the pole. The pole artery (arrow) arises from the middle cerebral artery opposite the thalamostriate arteries. It runs in an anterior direction and before crossing the anterior border of the pole divides into two branches that continue on the lower and lateral surfaces of the pole.

opposite to the thalamostriate arteries (Fig. 1). This artery is apparently identical with the anterior temporal artery described by RING, and the arteria temporalis polaris described by VANDER EECKEN (referred to as the temporal pole artery). Only in a few cases was more than one artery present. The artery runs in an anterior direction towards the apex of the pole. Before crossing the anterior border it usually divides into a number of branches, most of which pass fairly close to the vertex to continue on the lower and lateral surface of the pole. The medial surface is only supplied by small branches.

A review of one hundred normal angiograms disclosed that the pole arteries were always filled when the injection had been made into the internal carotid artery, although this was sometimes apparent only after subtraction. When the common carotid artery had been injected, the interpretation was made more difficult by the superimposition of branches of the external carotid artery. In a few of these cases, the pole arteries could not be identified with certainty.

The vessels are best seen in a late arterial phase (Fig. 2). In the lateral view they are projected over the sphenoidal sinus and mainly follow the border of the middle fossa. The vessels cross the gyri and dip down in the sulci, and as a consequence have an undulating course (Fig. 3). The smallest distance between the *vessels and the anterior border of the middle fossa was never more than 7 mm,* and only exceptionally exceeded 4 mm.

The vessels become fairly thin on the lower surface of the pole, and their extension towards the floor of the fossa could be evaluated only after subtraction. The floor of the middle fossa is however not clearly seen in a lateral view of the skull. The distance between the vessels and the floor of the fossa may be



Fig 5 a) Glioma of the temporal lobe lateral view (subtraction) The pole artery (arrows) is wider and more arched than usual its first part being displaced upwards the distal part follows close to the walls of the fossa b) Extracerebral haematoma lateral view (subtraction) The lesion extends below the temporal pole the pole artery is absent from its usual location in the middle fossa it is displaced upwards and superimposed by vessels in the Sylvian fissure

a b

Fig 6 a) Meningioma in the most medial part of the middle fossa a.p view (subtraction) The pol artery (arrow) is displaced laterally b) Pterion meningioma, a p view (subtraction) The pole artery (arrow) is displaced medially



Fig 4 Normal angiogram a p view (subtraction) The tube was tilted cranially about 30 in relation to the orbitomeatal line the pole artery (arrow) was projected free from other Sylvian vessels and is seen running towards the apex of the pole

estimated by drawing a line from the upper wall of the internal carotid artery, where it leaves the carotid canal, to the lower margin of the orbit The end points of this line are well defined and fix the line approximately at the level of the floor of the middle fossa The distance between the vessels on the lower surface of the pole and this line usually measured 6 mm, or less, and never exceeded 10 mm

The most suitable a p projection appears to be the half axial view, with the tube tilted cranially about 30° to the orbitomeatal line In this projection the pole artery runs in a downward direction towards the apex of the pole and will be projected free from other Sylvian vessels (Fig 4)

Theoretically it would seem that the appearances of these pole arteries should be useful for a differentiation between extracerebral and intracerebral lesions An intracerebral lesion should give the pole artery an arched and stretched course close to the walls of the middle fossa because of the increased volume of the pole An extracerebral lesion should on the other hand displace the artery from the walls of the fossa

These theoretical speculations have proved to be true in the cases so far examined of space occupying lesions of the middle fossa Intracerebral lesions of sufficient size invariably caused stretching and arching of the pole artery In addition to the increased arching of the artery in cases of intracerebral tumors the

ZUSAMMENFASSUNG

Die Anatomie der Gehirngefasse des Schlafenlappens wurde an anatomischen Praparaten und an Angiogrammen eingehend studiert Die Analyse des Gefassbildes des Schlafenlappens ist von grosser Bedeutung fur die Diagnose von Tumoren der mittleren Schadelgrube insbesondere bei der Unterscheidung zwischen intra und extra-cerebralen Lasionen.

RÉSUMÉ

Les auteurs ont étudie l anatomie vasculaire du pole du lobe temporal sur des pieces d autopsie et sur des angiographies cliniques Les arteres qui vont au pole temporal peuvent servir au diagnostic des lesions expansives dans la fosse moyenne et en particulier au diagnostic differentiel entre affections extracérebrales et intracérébrales

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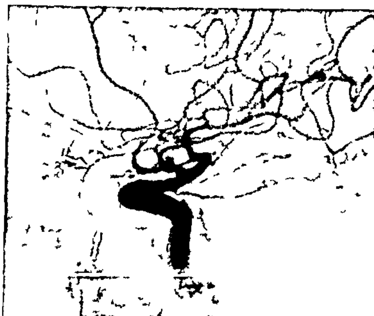


Fig 7 Lateral view (subtraction) in a case of trauma The distance between the pole artery (arrows) and the wall of the middle fossa is increased by an extracerebral haematoma Furthermore the pole artery is more arched than usual indicating increase in volume of the pole This was confirmed on operation besides an extracerebral haematoma contusion of the pole was revealed

artery has been wider than normal even in cases where no increased vascularity of the tumor could be demonstrated (Fig 5a)

Extracerebral lesions extending below the temporal pole and pushing the pole upwards also displace the pole artery so that it often is superimposed by vessels in the Sylvian fissure and therefore cannot be clearly seen in the lateral view (Fig 5b) Tumors located mainly medially or laterally in the middle fossa push the pole to the opposite side and the pole artery is displaced respectively laterally or medially (Fig 6)

A careful study of the temporal pole artery is also of value in traumatic cases, in the often difficult differentiation between extracerebral and intratemporal haematomas or contusions (Fig 7)

An investigation of the diagnostic value of the temporal pole artery in lesions of various nature and location is in progress

SUMMARY

The vascular anatomy of the temporal pole has been studied in autopsy specimens and in clinical angiograms The radiographic appearances of the arteries to the temporal pole have been found valuable in the diagnosis of space occupying lesions in the middle fossa especially for a differentiation between extracerebral and intracerebral lesions



Fig 1 a) Early arterial phase Linear defect (arrows) representing a small clot injected with the contrast medium b) A p projection Internal carotid aneurysm for which a common carotid artery clamp had been appl ed The middle cerebral artery previously open now has an occlusion with a convex proximal margin indicating an embolus.

patient at the time of angiography The age range and average age of these patients were tabulated and correlated with clinical change The presence or absence of early venous filling was evaluated and also correlated with clinical change Finally the needles used for the angiographic procedure in the latter fourteen patients were studied

Angiographic findings

Intra arterial filling defects indicate the presence of a foreign material presumably a clot introduced during or prior to injection of the contrast material This was seen in nine of the fourteen patients and an example is given in Fig 1a These intraarterial linear defects due to clot must be differentiated from defect due to flow phenomena or spiral filling The sharply defined ends of the clot are a help in differentiating it from the latter defects

The classic radiographic appearance of an embolus in a larger artery is well known As shown in Fig 1b there is an abrupt obstruction to the distal flow of the contrast material and the proximal convex end of the embolus is outlined identifying its intraluminal position This type of defect is often seen in the middle cerebral artery Careful evaluation of this type of obstruction may show that distal portions of the embolus have lodged in a bifurcation, and as the contrast material seeps by the initial block the embolus may be faintly outlined This is exemplified in Fig 2 A proximal convex border carefully analyzed is actually

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ANGIOGRAPHIC DIAGNOSIS OF SMALL-VESSEL CEREBRAL EMBOLI

by

D O DAVIS, C L RUMBAUGH and J M GILSON

During the course of an experimental study of the effects of autologous emboli on the dog brain, it became evident that the angiographic changes observed could be applied in the study of the human cerebral angiograms (RUMBAUGH & DAVIS) These changes led to the recognition of small vessel cerebral emboli in a number of clinical cases Clinical findings in these cases, changes in the neurologic status during a procedure, or an actual demonstration of an intravascular clot at the time of injection of contrast material, also led to a confident diagnosis of small vessel occlusion secondary to the embolus Some of the changes observed are angiographically illustrated in this paper and a few comments will be made on their correlation with clinical data

Material and Methods Cerebral angiograms of six patients with firm criteria for naturally occurring pre angiographic embolic phenomena were evaluated Fourteen patients with angiographic findings corresponding to those seen during experimental embolization in animals, or with concomitant emboli injected with the contrast material, were studied The neurologic status of all the patients was assessed Arterial obstruction in areas of the brain, classified as frontal, fronto-parietal, parietal, and occipital, was correlated with the neurologic status of the



Fig 3 Close up view of last major branch of middle cerebral artery Large embolus at bifurca tion (arrows) primarily lodged in one branch b) Slight tapering of artery (arrow) which is blocked distally slow flow of contrast medium through the lumen

emboli LASSEN (1966) has emphasized the luxury perfusion of the brain a concept which suggests paralysis of auto-regulation This causes a shunting of arterial blood to the venous side which is reproduced angiographically by the early appearance of contrast medium in the cerebral veins

Of interest is the demonstration in Fig 4 of an early filling frontal vein seen only 1 5 to 2 0 seconds after injection which indicates the speed of *occurrence* of these shunts since the vascular injury could have occurred at the time of injection This early filling is not surprising Experimental work by RUSSELL (1966) has shown that embolization of the cerebral arterial circulation may cause immediate venous drainage of bright *red blood* which corresponds to the angiographically demonstrated early filling of veins

Clinical findings

Of the fourteen patients with emboli occurring *during* angiographic procedures seven showed neurologic changes and seven were unchanged (see Table) Comparison of the location of the embolus with the neurologic status was made There was a tendency toward involvement of larger areas of the brain in the patients with neurologic change as might be expected Comparison revealed that those patients who developed a neurologic deficit were of an age range and average



Fig 2 a) Lucent defect (arrows) in proximal middle cerebral trunk with legs of clot saddling a bifurcation b) Close up of the embolus

a saddle embolus lodged at a bifurcation of the proximal cerebral artery This is quite similar to a well recognized phenomenon in the pulmonary artery

Less well known is the configuration seen in Fig 3a Some emboli, rather than straddling the bifurcation, will lodge primarily in one branch of a bifurcation, more or less completely occluding it The proximal protrusion of the embolus into the parent channel causes a half moon shaped filling defect, if seen in profile This appearance may be deceptive for two reasons First, the obstruction, if not seen totally in profile, may be overlooked entirely The only clue to its occurrence will be an unusual abrupt change in the caliber of the vessel as it bifurcates, because the vessel divides but only one branch will be seen (BATES & BOOKSTEIN 1966) Second, proximal protrusion of the embolus may indent the contrast column and suggest a raised plaque at the side of the vessel, initiating a false diagnosis of arteriosclerotic change

Tapering of an obstructed or slow flow vessel is occasionally seen, and allegedly is secondary to thrombosis (RING 1966) Observations made during this series indicate that tapering is also seen in arteries obstructed by emboli, which would not be unexpected It is probably due to dependent layering of the contrast material with slow flow distally or perhaps to slow flow of the contrast material through the center of the arterial lumen (Fig 3 b) It should not be mistakenly labeled spasm since serial films eventually will show a normal arterial lumen

Early filling of cerebral veins has been demonstrated many times during serial angiography Arteriovenous malformations and neoplasms are the cause of most of those seen Early venous filling was found in four of the fourteen angiographic examinations with procedural emboli, and in four of six naturally occurring



Fig 4 a) Lateral projection of early arterial phase showing blocked artery (→) and irregular structure (↦) shown to be a vein on the later film b) This early vein (↔) occurred acutely coinciding with the injection of the contrast medium and indicates the speed with which they may occur

tant The radiologic changes tabulated p 268 seen in patients with known emboli should be useful in the future Serial angiography must be performed for this evaluation since the retention of contrast material by obstructed arteries and early venous filling can only be diagnosed on sequential films. The radiographic technique must be of superior quality since the size of the blocked vessels and their terminal configurations may be very small Also for optimal filling of the vessels selective injection of the contrast material into the indicated carotid artery should be performed

Confirmation of the work of others is suggested by our series showing blocked vessels during the time of angiography According to ZATZ et coll (1965), the absence of a branch vessel may be indicative of an embolus BATES & BOOKSTEIN noted the slowing of flow in an originally patent artery while LANNER & ROSENGREN (1964) have emphasized that in all cases of intracerebral vascular occlusions it is a rule that the vessel peripheral to the occlusion will be filled in a retrograde direction via anastomoses

The procedures producing emboli in these cases were lengthy which would tend to confirm the observations by ALLEN et coll (1965) The absolute demonstration of intra arterial emboli is however a more reasonable explanation of the neurologic deficits which may occur While no statistical survey is possible under our present circumstances it is a subjective impression that most if not

Table

Needle emboli occurring in fourteen patients with angiographic findings

Case	Age	Location	Early vein
Clinically unchanged			
1	27	FP	+
2	7	MCA	0
3	24	P	+
4	8	P	0
5	38	F FP P O	+
6	19	P O	0
7	57	FP P	0
Clinically changed			
8	69	O	+
9	65	P	0
10	46	FP P	+
11	41	P O	0
12	36	F FP P O	+
13	38	F O	0
14	50	FP P	+

age considerably higher than those in whom no neurologic deficit occurred Presumably this would indicate increased availability of leptomeningeal and other collateral circulation to perfuse the area in which the primary circulation was occluded Of interest is the incidence of early veins in the two groups of patients, no difference was noted However, in those patients with pre angiographic, i e naturally occurring embolus, the incidence of early veins was considerably higher, being seen in four of six These patients had involvement of more extensive areas of the brain than those in whom the emboli occurred during a procedure The former patients also showed a more severe neurologic deficit than those in whom the needle emboli occurred, and the clearing of the deficit was very slow There tended to be very rapid clearing of the neurologic deficit in the seven patients who suffered needle emboli Only one of these retained a deficit longer than two days following the procedure

Discussion

Evaluation of emboli to the arteries of the brain will assume greater importance as more patients with the clinical diagnosis of stroke are angiographically evaluated Any aid in the diagnosis of the type of event causing the stroke is impor

Halfte der untersuchten Falle mit solchen Emboli hatten neurologische Storungen meistens vorubergehende wahrend die andere Halfte keine Zeichen klinischer Veranderungen aufwiesen Die fruhzeitige Fullung von Venen wird diskutiert und die Notwendigkeit die Injektionsnadel sorgfaltig zu uberwachen wird betont

RÉSUMÉ

Les auteurs etudient et illustrent par des exemples certains des signes angiographiques de l obstruction sur l apparition de ces embolies dans des cas d angiographie cerébrale au moyen d une aiguille a hub ouvert La moitie des patients qui ont eu de ces embolies ont presente des signes neurologiques déficitaires la plupart transitoires alors que l autre moitie des malades qui avaient de telles embolies n ont presente aucun signe clinique decelable Les auteurs etudient le retour veineux precoce Enfin ils insistent sur la necessite d entretenir soigneu ement les aiguilles

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ZATZ L M IANNONE A M and ECKMAN P B Observations concerning intracerebral vascular occlusions Neurology 15 (1965) 389

all, of the cases suffering neurologic deficits during angiography show multiple small vessel emboli upon evaluation of the angiogram made at that time. If further study indicates this to be the case, other causes such as spasm need not be invoked, and a concentration on care of the needle can be intensified.

Parenthetically, with respect to the needle, it is of interest that our findings tend to confirm those of BATES & BOOKSTEIN. Although the great majority of our cases are injected with a modified cournand needle (obtained from Becton Dickinson, Rutherford, New Jersey), in which the inner cannula extends back proximal to the hub, the great majority of the emboli were seen after injection through a non cournand type needle, that is, an open hub needle. These needles form clot in the sump of the hub, and its introduction takes place at the time of contrast material injection. However, the occurrence of a few emboli while using the regular modified cournand needle emphasizes the necessity for careful observation and care of the needle. Frequent intermittent flushing must be performed if the inner cannula of the modified cournand needle is removed. Perhaps this is the best method since it forces the attention of the physician on the patient at frequent intervals. If this must be foregone, it is our feeling that a blunt tight fitting stylette should be inserted and left in the needle between injections.

Either of these maneuvers will eliminate clot formation in the needle shaft and will reduce or eliminate embolic phenomena occurring during the angiographic procedure. If a teflon needle with inner hub cannula is utilized, the latter of the above alternatives must be followed.

Acknowledgement

In the course of this investigation J. M. Gilson was a NINDB Special Fellow No. ? F11 NB 1733 02. The work was in part supported by USPHS grants Nos 5 TO 1 NB 05599 and 5 PO 1 NB 06833.

SUMMARY

Angiographic findings in embolic blockage of small vessels of the brain are discussed and illustrated. Emphasis is placed upon the occurrence of such emboli in instances of cerebral angiography utilizing an open hub needle. Half the number of cases evaluated with these emboli suffered neurologic deficits, mostly transient, while the other half had no discernible clinical change. The appearance of early filling veins is discussed and the necessity of careful needle maintenance is emphasized.

ZUSAMMENFASSUNG

Angiographische Befunde bei Blockierung durch Emboli der kleinen Gefasse des Gehirns werden diskutiert und illustriert. Besonders wird das Auftreten solcher Emboli während angiographischen Untersuchungen mit Benutzung von Nadeln mit offenen Hub betont. Die



Fig 1 a) L angiograph e carotidienne objective un capillary blush traduisant la presence d un meningiome temporal b) La phlebographie orbitaire re ela une interruption du flux opaque au ni eau du segment posterieur de la veine ophtalmique Un tel arret temoigne d une compression tumorale de la reg on du sinus caverneux jusqu à l interieur de l orbite

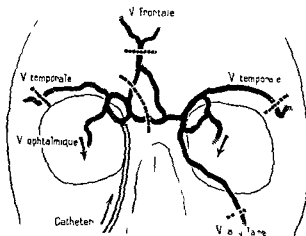


Fig 2 Les lignes n po ntille ind qu nt les endro ts ou la compression m canique peut etre exercee pour orienter le flux opaque elect vement dans le systeme veineux de la base du crane Si la comp ession est exercee sur les deux veines temporales et s r les veines frontal s l on obtient l opacifica tion d s d ux veines opht lmiques et des deux sinus caver n ux Si la compress on est par contre appliquee au niveau de la eine temporale homolaterale et su vant la disposition de la l gne en pointill incurvee seule la eine ophtalmique droite est opacifi e et à partir d elle le sinus caverneux du m me cote

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PHLÉBOGRAPHIE ORBITAIRE DANS L'ÉTUDE DES TUMEURS DE LA BASE DU CRÂNE

par

D. DILENGE, A. RAMÉE, J. SIMON et M. SACHS

La phlébographie orbitaire de technique simple et, d'après notre expérience, encore sans danger, peut être considérée comme un examen intéressant dans l'étude des tumeurs de la base du crâne.

Déjà, dans trois cas de tumeurs intra-crâniennes rétro-orbitaires nous avions observé une interruption manifeste du courant veineux dans la région du sinus caverneux. Les caractéristiques morphologiques constatées nous avaient permis une meilleure définition de la localisation et des rapports de la tumeur. Un quatrième cas ne comportait qu'une image plus douteuse.

Ainsi, dans notre premier cas, le contour antérieur de l'image tumorale, mise en évidence par l'angiographie carotidienne, coïncidait avec un arrêt du produit de contraste dans le système veine ophtalmique-sinus caverneux, arrêt qui confirmait l'extension de la compression tumorale jusqu'à l'intérieur de l'orbite; en effet, l'interruption se faisait au niveau de segment postérieur intra-orbitaire de la veine ophtalmique (Fig. 1).

Dans notre second cas, où l'artériographie avait fait porter le diagnostic de méningiome de la petite aile en variété interne, on constatait à l'intervention un envahissement du sinus caverneux. En fait, celui-ci aurait pu être soupçonné sur la phlébographie qui avait montré un défaut d'injection de ce sinus.



Fig. 1. a) L'angiographie carotidienne objective un « capillary blush » traduisant la présence d'un méningiome temporal. b) La phlébographie orbitaire révéla une interruption du flux opaque au niveau du segment postérieur de la veine ophtalmique. Un tel arrêt témoigne d'une compression tumorale de la région du sinus caverneux jusqu'à l'intérieur de l'orbite.

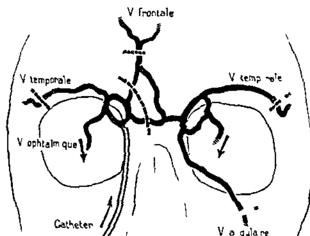


Fig. 2. Les lignes en pointillé indiquent les endroits où la compression mécanique peut être exercée pour orienter le flux opaque électivement dans le système veineux de la base du crâne. Si la compression est exercée sur les deux veines temporales et sur les veines frontales, l'on obtient l'opacification des deux veines ophtalmiques et des deux sinus caverneux. Si la compression est par contre appliquée au niveau de la veine temporale homolatérale et suivant la disposition de la ligne en pointillé incurvée, seule la veine ophtalmique droite est opacifiée et à partir d'elle le sinus caverneux du même côté.



Fig. 3. a) L'opacification de la veine ophtalmique après compression semble interrompue au niveau de la fente sphénoïdale. b) Une compression plus énergique et mieux répartie permet de constater que l'interruption du système veineux n'était complète qu'au niveau de la portion antérieure du sinus caverneux.

Notre troisième cas était un réticulosarcome de la base pour lequel l'angiographie carotidienne ne donnait pas de résultat concluant, mais le blocage au niveau du sinus caverneux confirmait la présence de la tumeur et précisait son extension. On pouvait définir aisément sa limite antérieure à la partie moyenne du sinus, en arrière du confluent avec le sinus de Breschet qui s'injectait par voie rétrograde.

C'est à partir de ces trois cas que nous avons voulu exploiter de façon plus systématique et plus rationnelle, les données de la phlébographie orbitaire. Tout naturellement, nous avons donc recherché à améliorer la méthode et c'est ainsi que notre expérience récente nous a permis de constater l'intérêt qu'il y avait à utiliser un système de compression mécanique pour exclure les voies de dérivation gênantes (Fig. 2).

En effet, le plus souvent le produit de contraste injecté dans la veine angulaire, a tendance à diffuser en dehors de l'orbite dans les veines frontales et temporales, dans les veines faciales et à travers la veine transverse prénasale dans la circulation orbitaire contro-latérale. Ces dérivations superficielles sont facilement accessibles à la compression.

L'exclusion de ces réseaux, au moment de l'injection, permet une opacification



Fig 4 Phlebographie gauche dans un cas de tumeur du glomus jugulaire a) A la suite d une premiere compression la plus grande partie du produit de contraste se trouve injectee du cote droit et seule la veine ophtalmique est opacifiee du cote gauche b) Une compression comprenant la veine transverse pre nasale fait diriger tout le produit opaque dans la veine ophtalmique et dans le sinus caverneux du cote gauche ainsi que dans le systeme veineux avoisinant la tumeur

optimale de la veine ophtalmique et a partir d elle du sinus caverneux et de ses collaterales Encore faut il que la compression soit la plus efficace possible et adaptee a chaque cas En effet le resultat peut etre different et l interpretation meme modifiee suivant le degre de la compression

Ainsi dans un cas (Fig 3) nous avions tout d abord obtenu en croyant comprimer convenablement le reseau superficiel une bonne opacification d une veine ophtalmique qui paraissait interrompue au niveau de la fente sphenoidale En fait une deuxieme serie de cliches sous compression plus energique et mieux repartie permettait de prouver que l interruption du systeme veineux n etait complete qu au niveau de la partie anterieure du sinus caverneux

Mais le role de la compression ne nous parait pas devoir se limiter a une plus ou moins grande definition du siege exact de l obstruction d une veine intracranienne Elle nous semble permettre en outre une meilleure exploration de certains territoires veineux dans lesquels les modifications hemodynamiques dues au voisinage de la tumeur seraient responsables de leur mauvaise opacification

Ainsi, dans une tumeur du glomus jugulaire, hypervascularisée, riche en fistules artérioveineuses, le produit de contraste ne dépassait pas la fente sphénoïdale du côté malade et passait électivement dans les veines du côté sain (Fig. 4) si l'on se contentait d'une compression habituelle. Une compression plus sélective permettait une opacification optimale de toute la veine ophtalmique et du sinus caverneux homolatéral. L'analyse morphologique de ces images objectivait une déformation du sinus caverneux et un défaut d'injection du golfe de la jugulaire. On constatait de plus que le flux veineux suivait des voies inhabituelles.

Conclusion

La phlébographie orbitaire avec compression mécanique rationnelle des veines superficielles (frontales, temporales, et faciales), nous a paru apporter un certain nombre d'éléments susceptibles de mieux étudier la circulation veineuse de la base du crâne et partant de préciser certains critères d'opérabilité des tumeurs de la base.

RÉSUMÉ

La phlébographie orbitaire, technique simple et sans danger d'après notre expérience, autorise une meilleure définition du siège de l'obstruction veineuse en présence d'une tumeur de la base du crâne. Elle paraît pouvoir également objectiver certaines modifications hémodynamiques de la circulation veineuse avoisinante.

SUMMARY

Orbital phlebography is considered a simple and safe method permitting good evaluation of venous occlusions and of the venous circulation in the vicinity in cases of tumour of the base of the skull.

ZUSAMMENFASSUNG

Die Technik bei orbitaler *Phlebographie* ist einfach und *die Untersuchung* kann ohne Risiko durchgeführt werden. Sie erlaubt eine gute Definition und Lokalisation der Okklusion von Venen und der angrenzenden venösen Zirkulation in Fällen von Tumoren der Schädelbasis.

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FROM THE DEPARTMENTS OF NEURORADIOLOGY (DIRECTOR F EL NADI) AND NEUROSURGERY (DIRECTOR A EL BANHAWY), MAADI HOSPITAL CAIRO, EGYPT

TRIDIMENSIONAL ANGIOGRAPHY OF ANTERIOR CEREBRAL ARTERY IN SUPRASELLAR TUMOURS

by

FOUAD EL NADI and AHMED EL BANHAWY

Encephalography is generally accepted as the procedure of choice in the investigation of suprasellar tumours (LINDGREN 1954) although carotid angiography is now being used more often when new growths in this region are considered likely (CHASE & TAVERAS 1961) Some authors (DRIESEN & SCHMIDT 1959) have even gone so far as to claim the superiority of the latter procedure

Material The present work is based upon a study of normal and abnormal internal carotid angiograms obtained over a period of six years These consisted of 360 normal carotid angiograms and 58 angiograms of suprasellar and anterior third ventricle tumours they included 26 cases of chromophobe pituitary adenomas 20 cases of craniopharyngiomas 9 cases of suprasellar meningiomas and 3 cases of gliomas of the hypothalamus

The suprasellar arterial arch The nomenclature suggested by LINDGREN is employed Thus the anterior cerebral artery is the part lying between the bifurcation of the internal carotid artery and the anterior communicating artery the artery from this point around the corpus callosum being called the pericallosal artery the latter is beyond the scope of our discussion

The chiasmal segment of the anterior cerebral artery being in close relationship

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The chiasmal segment of the anterior cerebral artery being in close relationship



a b

Fig 1 De-capped skull with wire in the internal carotid artery and in the proximal segments of both the anterior and the middle cerebral arteries The wire segment of the anterior cerebral artery was displaced forwards a) First a p view Slight downward displacement b) Second a p view Slight upward displacement



a b

Fig 2 The wire segment of the anterior cerebral artery was displaced upwards and forwards a) First a p view Almost no displacement b) Second a p view Marked upward displacement

to the diaphragma sellae is affected at an early stage by an expansive process in this region

The two anterior cerebral arteries—with the anterior communicating artery in between—are considered as a single variable arch with the ends fixed in the region of the bifurcation of the carotid siphon Completing the arch on both sides is the supracavernous portion of the carotid siphon which is partially fixed at the same point (i e the bifurcation of the internal carotid artery) and completely anchored more proximally as it enters the cavernous sinus

The arch formed by both supracavernous segments of the carotid siphons both anterior cerebral arteries and the anterior communicating artery is thus displaced as one unit by an expansive process in the region Logically, the maximal displacement should take place at the point furthermost from its fixed ends i e at the centre of the arch formed by the anterior communicating artery and the minimal displacement near the points of fixation i e at the siphon The shape of the displacement is modified by the fact that the anatomic constituents of the arch do not lie in the same geometric plane

Angiographic technique The plane of this suprasellar arterial arch forms an angle of about 10 degrees upwards from the plane of the orbito-meatal line If the roentgen rays pass in the same plane as an arch or a circle the effect on the film will be a straight line On the other hand, if the rays are directed at right angles to the plane of the arch or circle the full curvature of the arch and the completely round circumference of the circle will be depicted Finally if the rays pass at various planes in between the curvature of the geometric arch or circle will be reduced in proportion to the proximity of the rays to its actual plane To apply this to the chiasmal segments if the rays happen to lie in a plane at an angle of about 10 degrees cranial to the orbito-meatal line this segment will be projected as a straight line On the other hand if the tube is moved caudally to form an angle of 80 degrees with the orbito-meatal line the full curvature of the chiasmal segment will be projected The former projection (10 degrees cranial) is near to the generally used a p projection (15 to 20 cranial) while the latter view (80 caudal) is difficult to interpret without subtraction as the arteries will be masked by the bone of the base of the skull To reach a compromise and keeping in mind the various possible pathologic displacements two a p projections were chosen with the aim of obtaining an all round view of the chiasmal curve of the anterior cerebral artery in two planes at about right angles

It was finally decided to obtain three arteriographic series in all cases considered to have suprasellar tumours viz a lateral view a first a p view—upper half axial projection and a second a p view—lower half axial projection

It is obvious that the lateral view will afford little information as far as the

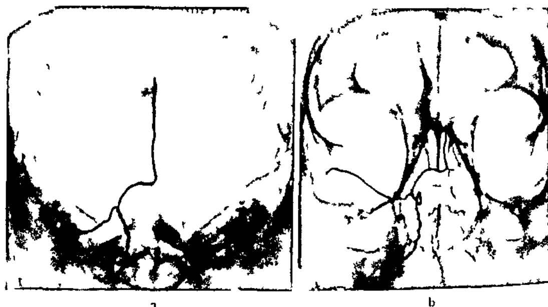


Fig 3 The wire segment of the anterior cerebral artery was displaced upwards a) First a p view Slight upward displacement b) Second a p view Slight upward displacement



Fig 4 The wire segment of the anterior cerebral artery was displaced upwards and backwards a) First a p view Marked upward displacement b) Second a p view Almost no displacement

anterior cerebral artery is concerned since the segment in question will be projected almost end on The first a.p view is obtained with the central ray forming an angle of about 35 degrees cranially with the orbito meatal line The second a p view is obtained with the central ray passing through the nasion to form an angle of about 35 degrees caudally with the orbito-meatal line

The two a.p series are almost at right angles to each other It was found that a difference of 70 degrees was technically optimal

The wire artery' experiment The following experiments were made to illustrate the relative value of each of the two half axial projections on displacement of the anterior cerebral artery in various directions A piece of wire was threaded into an open de capped skull to represent the internal carotid artery and the proximal segments of both its main branches The transverse wire-segment of the anterior cerebral artery was bent and stretched in various directions representing the various possible displacements of the anterior cerebral artery both half axial views then being obtained for each displacement The results were as follows

Forward displacement (Fig 1) In the first a p view there was a slight downward displacement and in the second a p view a slight upward displacement

Upward and forward displacement (Fig 2) In the first a p view there was almost no displacement and in the second a p view marked upward displacement

Upward displacement (Fig 3) In the first a p view there was a slight upward displacement and in the second a p view a slight upward displacement

Upward and backward displacement (Fig 4) In the first a.p view there was marked upward displacement and in the second a p view almost no displacement

Backward displacement (Fig 5) In the first a p view there was slight upward displacement and in the second a.p view a slight downward displacement

It is therefore possible to determine the direction of displacement and hence the site and origin of an expansive process by analyzing the displacements in the two projections and by means of a simple geometrical summation

Displacements occurring with different tumours

The suprasellar tumours were divided into the following groups (EL BANHAWY & EL NADI 1962) strictly intrasellar tumours (1), secondary suprasellar tumours suprasellar extension of intrasellar tumours) (2) and primary suprasellar tumours (3)

1 The strictly intrasellar tumours cause no changes in the anterior cerebral arteries



Fig 5 The wire segment of the anterior cerebral artery was displaced backwards a) First a p view Slight upward displacement b) Second a p view Slight downward displacement



Fig 6 Chromophobe adenoma with suprasellar extension a) No displacement of anterior cerebral artery in the first a p view b) Upward displacement of the artery in the second a p view These observations indicate that the anterior cerebral artery is displaced upwards and forwards

2 In the cases of secondary suprasellar tumours the degree of displacement is dependent on their size and predominant direction of their spread Chromophobe adenomas in our material generally displaced the anterior cerebral artery upwards and forwards less commonly directly upwards while secondary suprasellar craniopharyngiomas generally displaced it upwards and backwards much less commonly upwards and forwards

3 The group of primary suprasellar tumours could be divided into two subgroups tumours arising at or below the level of the optic chiasm (A) and tumours arising above the level of the optic chiasm (B)

3 A The tumours arising at or below the level of the optic chiasm generally give rise to similar changes as those produced by secondary suprasellar growths

It was found that suprasellar meningiomas characteristically displace the anterior cerebral artery predominantly backwards but slightly upwards in a bow shaped curve This pattern of the anterior cerebral artery together with the backward and lateral displacement of the terminal part of the carotid siphon are almost pathognomonic angiographic signs of this neoplasm Suprasellar craniopharyngiomas may displace the artery in any direction although the displacement is usually upwards and backwards and only occasionally upwards and forwards

The characteristic feature of a craniopharyngioma would however appear to consist of extreme stretching of the anterior cerebral artery which instead of taking a curved course describes a straight line If both anterior cerebral arteries are demonstrated simultaneously they are seen to meet at a right or even an acute angle forming what is called a tent shaped shift

3 B Tumours arising above the level of the optic chiasm press of course on the optic chiasm and the anterior cerebral arteries from above Their characteristic feature is a caudally convex bow shaped course of the anterior cerebral artery

Conclusions

The projections described enable the three common suprasellar neoplasms to be more or less differentiated by the pattern of displacement of the anterior cerebral artery It should be emphasized however that other landmarks in the angiogram notably the last segment of the internal carotid artery produce complementary information

If the growth has displaced the anterior cerebral artery upwards and forwards as is usually the case in small chromophobe adenomas no displacement will be detected without the a p projections suggested (Fig 6)



Fig 5 The wire segment of the anterior cerebral artery was displaced backwards a) First a p view Slight upward displacement b) Second a p view Slight downward displacement

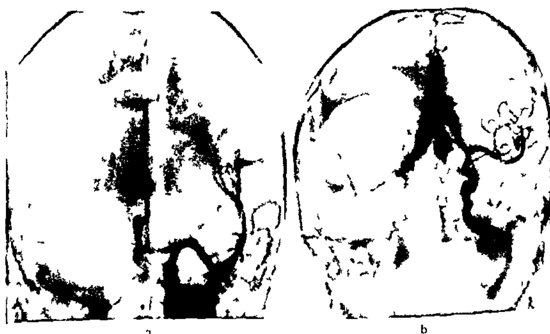


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FROM THE DEPARTMENT OF RADIOLOGY, THE UNIVERSITY OF MICHIGAN MEDICAL CENTER ANN ARBOR MICHIGAN U S A

SIZE OF VERTEBRAL ARTERY AND OF FORAMEN TRANSVERSARIUM OF AXIS

An anatomic study

by

TRYGVE O GABRIELSEN

LINDBLOM (1936) has stated that in order to obtain a measurement of the size of the vertebral artery one only has to measure the shortest diameter of the superior or approximately horizontal portion of the foramen transversarium of the axis on a roentgenogram The present study was done in an attempt to evaluate the validity of this statement Although LINDBLOM listed the total material which he used for a very comprehensive investigation of the vascular channels of the skull it is not entirely clear how much of his material was suited for an assessment of the relationship between the size of the vertebral artery and the size of the foramen transversarium of the axis

Material and Methods Twenty three male and two female adult cadavers with the axis and vertebral arteries well preserved were available for study No effort was made to establish the cause of death The cadavers were wrapped in cloth moistened with water but no other fluid By a femoral approach the arterial system had been injected with an aqueous suspension of red lead and starch shortly post mortem

The minimum and maximum internal diameters of the vertebral arteries were

SUMMARY

A material of 58 suprasellar growths was investigated angiographically using two ap views termed upper and lower half axial projections in addition to the lateral view It was possible with the aid of this technique to differentiate between the three most common suprasellar neoplasms, i e chromophobe adenomas meningiomas and craniopharyngiomas

ZUSAMMENFASSUNG

Ein Material von 58 suprasellären Tumoren wurde mit Angiographie untersucht wobei ausser der lateralen Aufnahme zwei anterioposterioren Aufnahmen die bzw die obere und die untere Projektion bezeichnet wurden zur Anwendung kamen Mit dieser Technik war es möglich zwischen den drei gewöhnlicheren Typen d h chromophoben Adenomen Meningiomen und Craniopharyngeomen zu unterscheiden

RÉSUMÉ

Les auteurs ont examiné 58 tumeurs suprasellaires par angiographie au moyen de deux incidences antero postérieures appelées projections semi axiales supérieure et inférieure et plus de l incidence de profil Cette technique a permis de distinguer les trois néoformations suprasellaires les plus fréquentes c est à dire les adenomes chromophobes les meningiomes et les craniopharyngiomes

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Table 1

Size of the vertebral arteries and the foramina transversaria of the axis

Size in mm	Number of specimens measured on the right side				Vertebral artery average right	Number of specimens measured on the left side				Vertebral artery average left
	Foramina minimum		Foramina average			Foramina minimum		Foramina average		
	Cadavers	Dried bones	Cadavers	Dried bones		Cadavers	Dried bones	Cadavers	Dried bones	
1 5					2					1
2 0					1					
2 5		1		1	2		1			3
3 0	1	3	1		7				1	3
3 5	1	5	1	2	9	1	6		2	11
4 0	1	12	1	9	3	1	13	2	6	6
4 5	4	38	3	12	1	1	26	1	13	
5 0	9	58	7	31		8	62	6	36	1
5 5	6	38	9	61		12	37	11	54	
6 0	3	16	3	26		1	18	4	32	
6 5		4		25		1	9	1	22	
7 0				7			2		8	
7 5				1			1			
8 0									1	
Total	25	175	25	175	25	25	175	25	175	25

measured bilaterally at their point of exit from the foramina transversaria of the axis The minimum and maximum diameters of the horizontal portion of the corresponding foramina were subsequently measured Similar measurements were made on the foramina of an additional 175 dried axis specimens These specimens, selected at random from a larger pool, were considered acceptable only if the foramen transversarium was intact bilaterally

All measurements were obtained with precision calipers directly on the anatomic material and not on roentgenograms Each measurement was made twice the second without knowledge of the result obtained previously The general appearance of the foramina transversaria of the axis as well as the arteries and accompanying veins was also noted

Findings

General observations The cephalic portion of the foramen transversarium had a fairly variable appearance It tended to assume an approximately horizontal

Table 2

Difference in size between right and left vertebral arteries and foramina transversaria of axis given in relation to number of specimens measured

Size difference	Foramina minimum		Foramina average		Vertebral artery average
	Cadavers	Dried bones	Cadavers	Dried bones	
Equal	7 (28%)	52 (29.7%)	6 (24%)	50 (28.6%)	9 (36%)
Rt > Lt	6 (24%)	50 (28.6%)	7 (28%)	59 (33.7%)	5 (20%)
0.5 mm	4	31	6	30	3
1.0 mm	1	8		14	1
1.5 mm		7	1	10	
2.0 mm	1	3		2	1
2.5 mm		1		2	
3.0 mm				1	
Lt > Rt	12 (48%)	73 (41.7%)	12 (48%)	66 (37.7%)	11 (44%)
0.5 mm	5	36	4	35	6
1.0 mm	5	23	6	17	1
1.5 mm	1	7	1	7	2
2.0 mm	1	5	1	6	2
2.5 mm		2		1	
3.0 mm					
Total	25 (100%)	175 (100%)	25 (100%)	175 (100%)	25 (100%)

orientation with respect to both a supine and an erect posture. Progressing from a medial to lateral position along the canal, the deviation from this orientation was almost always in a slightly dorsal and frequently also a caudad direction which turned cephalad closer to the meatus. The minimum diameter of the foramen transversarium most often consisted of an approximately ventral-dorsal diameter with the ventral end slightly cephalic in location relative to the dorsal end.

During the search for 175 well preserved dried axis specimens, 10 specimens (5.4% of 185) with an incomplete bony ring of the foramen transversarium were encountered. This condition was found four times on the left and six times on the right side. The incomplete part was always along the caudal and dorsal aspect of the canal. These bones were excluded from the material used for measurement purposes.

A venous plexus with one to three dominant veins accompanying the vertebral artery could usually be identified within the horizontal portion of the foramen transversarium of the axis. The artery favored a location at the periphery of the

Table I

Size of the vertebral arteries and the foramina transversaria of the axis

Size in mm	Number of specimens measured on the right side: Foramina minimum, Cadavers	Foramina minimum, Dried bones	Foramina average, Cadavers	Foramina average, Dried bones	Vertebral artery average right	Number of specimens measured on the left side: Foramina minimum, Cadavers	Foramina minimum, Dried bones	Foramina average, Cadavers	Foramina average, Dried bones	Vertebral artery average left
1.5					2					1
2.0					1					
2.5		1		1	2		1			3
3.0	1	3	1		7				1	3
3.5	1	5	1	2	9	1	6		2	11
4.0	1	12	1	9	3	1	13	2	6	6
4.5	4	38	3	12	1	1	26	1	13	
5.0	9	58	7	31		8	62	6	36	1
5.5	6	38	9	61		12	37	11	54	
6.0	3	16	3	26		1	18	4	32	
6.5		4		25		1	9	1	22	
7.0				7			2		8	
7.5				1			1			
8.0									1	
Total	25	175	25	175	25	25	175	25	175	25

measured bilaterally at their point of exit from the foramina transversaria of the axis. The minimum and maximum diameters of the horizontal portion of the corresponding foramina were subsequently measured. Similar measurements were made on the foramina of an additional 175 dried axis specimens. These specimens, selected at random from a larger pool, were considered acceptable only if the foramen transversarium was intact bilaterally.

All measurements were obtained with precision calipers directly on the anatomic material and not on roentgenograms. Each measurement was made twice, the second without knowledge of the result obtained previously. The general appearance of the foramina transversaria of the axis as well as the arteries and accompanying veins was also noted.

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General observations. The cephalic portion of the foramen transversarium had a fairly variable appearance. It tended to assume an approximately horizontal

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S e difference	Foramina minimum		Foramina average		Vertebral artery average
	Cadavers	Dried bones	Cadavers	Dr ed bones	
Equal	7 (28)	5? (?9 7)	6 (24)	50 (28 6)	9 (3( )
Rt> Lt	6 (24 o)	50 (28 6)	7 (28)	59 (33 7)	5 (20)
0 5 mm	4	31	6	30	3
1 0 mm	1	8		14	1
1 5 mm		7	1	10	
2 0 mm	1	3		2	1
? 5 mm		1		2	
3 0 mm				1	
Lt> Rt	12 (48)	73 (41 7)	12 (48)	66 (37 7)	11 (44)
0 5 mm	5	36	4	35	6
1 0 mm	5	23	6	17	1
1 5 mm	1	7	1	7	2
2 0 mm	1	5	1	6	2
2 5 mm		2		1	
3 0 mm					
Total	25 (100)	175 (100)	25 (100)	175 (100)	25 (100)

orientation with respect to both a supine and an erect posture Progressing from a medial to lateral position along the canal the deviation from this orientation was almost always in a slightly dorsal and frequently also a caudad direction which turned cephalad closer to the meatus The minimum diameter of the foramen transversarium most often consisted of an approximately ventral dorsal diameter with the ventral end slightly cephalic in location relative to the dorsal end

During the search for 175 well preserved dried axis specimens 10 specimens 5 4 % of 185) with an incomplete bony ring of the foramen transversarium were encountered This condition was found four times on the left and six times on the right side The incomplete part was always along the caudal and dorsal aspect of the canal These bones were excluded from the material used for measurement purposes

A venous plexus with one to three dominant veins accompanying the vertebral artery could usually be identified within the horizontal portion of the foramen transversarium of the axis The artery favored a location at the periphery of the

Table 3

Difference in size between the foramen transversarium of the axis and the corresponding vertebral a

Size difference	Frequency	
	Foramen minimum> Vertebral artery average	Foramen average> Vertebral artery aver
1 0 mm		
1 5 mm	5	2
2 0 mm	20	20
2 5 mm	17	17
3 0 mm	7	8
3 5 mm	1	2
		1
Total	50	50

bend of the foramen The veins had a chiefly opposite location Although the vertebral arteries were rather poorly filled with clotted blood and injected ma terial they did not appear to be in a grossly collapsed state There was a tendency for the periadventitial tissues to be most firmly attached to the periosteum where the arteries emerged from the bone In two instances when the minimum diam eter of the foramen exceeded the internal diameter of the artery by at least 2 5 mm, the arterial wall was quite thickened from arteriosclerotic change In none of the cadavers was any attempt made to examine the vertebral arteries for arteriosclerosis at other levels in the neck

Measurements All diameters have been recorded to an accuracy of 0 5 mm The average difference between the first and second measurements on the cadaver material was 0 19 mm for the arteries and 0 22 mm for the bony foramina It is assumed that comparable accuracy was obtained for the measurements made on the dried axis specimens Occasionally, the superior meatus of the foramen trans versarium flared widely The measurements were then taken at a greater depth within the horizontal portion of the canal

The results of all the measurements are summarized in Tables 1, 2 and 3 The average diameter of the foramen transversarium rather than the maximum diameter has been indicated and represents half the combined values of the minimum and maximum diameters Based on similar calculations, only the aver age diameter of the vertebral artery is shown The lumen of 43 of the 50 arteries was round on cross section The remaining 7 arteries demonstrated a difference of only 0 5 mm between the minimum and maximum diameters

In the three cadavers showing a 2.0 mm difference in size between the right and left vertebral arteries (see Table 2), the smaller artery measured 1.5 mm in diameter. Table 2 also demonstrates that there was a size difference of at least 1.5 mm between the right and left minimum diameters of the foramen transversarium in 28 (14 %) of 200 specimens.

Discussion

According to LINDBLOM (1936) the vertebral artery occupies the space at the periphery of the bend (superiorly and posteriorly) of the foramen transversarium of the axis and the vein a chiefly opposite position. Although the current study confirms this as a strong trend, there appears to be considerable variation in this relationship.

LINDBLOM has given the minimum diameter of the foramen transversarium of the axis as ranging between 3.0 mm and 7.0 mm for an average (not to be confused with the foramen transversarium average as used in this paper) size of 5.0 mm. Table 1 shows almost identical results. There does not seem to be any significant difference between the data obtained from cadavers as compared to dried bones.

Table 3 demonstrates that the minimum diameter of the foramen transversarium of the axis most frequently exceeds the internal diameter of the vertebral artery by 1.5 to 2.0 mm. LINDBLOM apparently examined the external diameters of the vertebral arteries. When allowance is made for this, the present study confirms as a strong trend his observation that the minimum diameter of the foramen transversarium of the axis is an index of the vertebral artery size. The vertebral artery average and the foramen transversarium average do not correlate quite as well. The foramen transversarium average is generally about 0.5 mm greater than the foramen transversarium minimum (see Table 1).

Because the cross section of an artery may be ovoid rather than round, the maximum internal diameter of the vertebral artery conceivably could be greater than the minimum diameter of the foramen transversarium of the axis. No such case was seen in the present material. For practical purposes one may conclude that the internal diameter of the vertebral artery is at least 1.0 mm smaller than the minimum diameter of the foramen transversarium of the axis (see Table 3). However, considerably greater discrepancy in size may exist. One would expect this to be the case especially in the presence of arteriosclerosis or other occlusive disease affecting the vertebral artery.

It should be emphasized that the present measurements were obtained on cadavers. Even if the exact size of the vertebral arteries might be different during life than post mortem, it seems reasonable to assume that the diameter of the

vertebral arteries probably would be altered to about the same degree in all the cadavers Such a situation would not invalidate the conclusion that the minimum diameter of the foramen transversarium of the axis tends to be an index of vertebral artery size

KRAYENBUHL & YASARGIL (1957) have compared the size of the right and left vertebral arteries in 400 cadavers and found them to be of equal size in 26 %, the left one larger than the right in 42 %, and the right one larger than the left in 32 % of the cases These percentage values are nearly the same as those obtained by comparing the size of the right and left foramina transversaria of the axis in the present study (see Table 2) Only a relatively small number of cadavers was included in the current material However, a comparison of diameter size on the right and left sides of these cadavers gave results which are similar for both the foramen transversarium minimum and the vertebral artery average (see Table 2)

KRAYENBUHL & YASARGIL (1957) found some cases with very small vertebral arteries bilaterally (0 75 %) or only on the left (4 5 %) or right (6 2 %) Of the 25 cadavers in the current study, 3 (12 %) had a vertebral artery lumen of 1 5 mm diameter on one side Table 1 shows that among the total material, the foramen transversarium minimum was 3 5 mm or less in 19 (9 5 %) of the specimens, it was never as small as 3 5 mm bilaterally

Conclusions

The minimum diameter of the superior or approximately horizontal portion of the foramen transversarium of the axis is a fairly good indicator of the size of the corresponding vertebral artery The minimum diameter of the foramen most frequently exceeds the internal diameter of the artery by 1 5 to 2 0 mm However, greater discrepancy in size between these two measurements may exist and would in fact, be expected whenever significant occlusive disease from arteriosclerosis or other causes involves the vertebral artery

Acknowledgement

All of the anatomic material used in this study was supplied by the Department of Anatomy (Director R T Woodburne) University of Michigan through the generosity of Thomas M Oelrich Associate Professor of Anatomy

SUMMARY

The vertebral arteries of 25 cadavers were measured at their point of exit from the foramina transversaria of the axis The size of the foramina was measured subsequently and correlated with the size of the corresponding vertebral arteries The size of the foramina transversaria of 175 additional dried axis specimens was also measured The data obtained from the combined anatomic material are analyzed

ZUSAMMENFASSUNG

Die Diameter der Aa. vertebralis wurden bei ihrem Abgang von dem Foramen Costotransversarium in 25 Kadavern gemessen und danach wurde die Grosse der Foramina gemessen und mit der Grosse der entsprechenden Arteria vertebralis korreliert Weiter wurde die Grosse der Foramina Costotransversaria in 175 getrockneten Proben gemessen Die Resultate dieses kombinierten anatomischen Materiales werden analysiert

RÉSUMÉ

L'auteur a mesure le diametre des arteres vertebrales de 25 cadavres a leur point de sortie des trous transversaires de l'axis Le diametre des trous a été mesure ensuite et mis en correlation avec le diametre des arteres vertebrales correspondantes L'auteur a mesure aussi le diametre des trous transversaires de 175 autres axis secs Il etudie les donnees provenant de ces pieces anatomiques

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FROM THE DEPARTMENTS OF RADIOLOGY AND ANAESTHETICS, ADDENBROOKE'S HOSPITAL, HILLS ROAD, CAMBRIDGE, ENGLAND

INFLUENCE OF CARBON DIOXIDE TENSION ON THE ANGIOGRAPHIC APPEARANCE OF INTRACRANIAL TUMOURS

by

ROSEMARY A GRANGE, T DESMOND HAWKINS and J R SAMUEL

The effect of uncontrolled changes in arterial carbon dioxide tension on the cerebral angiogram performed under general anaesthesia must have been observed by many experienced radiologists KREUGER and his colleagues (1963) described in detail the effect of changes in end expiratory carbon dioxide tension on the normal appearance of the cerebral vessels Wide variations in cerebral blood flow have been observed during angiography under routine general anaesthesia (AMUNDSEN, AMUNDSEN & REFSUM 1966) The authors ascribe this to variations in the arterial P_{CO_2}

A study is in progress to assess the influence of controlled variation of the end expiratory carbon dioxide tension on the cerebral vasculature of patients with intracranial tumours, with particular reference to the demonstration of tumour vessels

Technique Angiography is performed by direct puncture of the common carotid artery under general anaesthesia The patient is not premedicated but immediately prior to induction an intravenous injection of atropine 0 6 mg and

Table

Comparison of low versus high $PaCO_2$ series in the demonstration of tumour vessels

Tumour type	Number of cases	Low $PaCO_2$		
		No change	Improved	
			+	++
Glioma	14	4	3	7
Meningioma	6	1	2	3
Total	20	5	15	

pethedine 50 mg is given Induction is with thiopentone (150 to 500 mg) and relaxation is obtained with d tubocurarine (30 to 45 mg) After spraying the larynx with 4 % lignocaine the trachea is intubated with a cuffed tube Ventilation is controlled using a Manley ventilator delivering a total gas flow of 15 litres per minute (5 litres of oxygen and 10 litres of nitrous oxide)

In all cases the end expiratory carbon dioxide concentration is measured by a Beckman infrared CO analyser This corresponds closely to the carbon dioxide tension in the alveolar gas and hence to that in the arterial blood The blood pressure and pulse rate are recorded throughout the procedure and in all cases very little variation has been noted

One rapid film series is obtained in the lateral projection when hyperventilation has produced an end-expiratory carbon dioxide concentration of between 3 % and 4 % This corresponds to an arterial carbon dioxide tension of 15 to 22 mm Hg and is considerably lower than the normal level of 40 mm Hg

A second rapid film series is taken without any alteration in ventilation other than the addition of CO to the inspired gas mixture Enough is given to raise the end-expiratory CO concentration to between 8 % and 10 % which corresponds to an arterial carbon dioxide tension of 50 to 65 mm Hg The order in which the two film series are taken is varied from patient to patient

Results

Of 38 patients studied to date thirty two have shown the previously reported changes of the normal cerebral vessels in response to alterations in carbon dioxide tension (KREUGER et coll 1963) The remaining six patients all of whom had markedly raised intracranial pressure showed no change between the two series other than in tumour circulation Twenty seven patients proved to have an

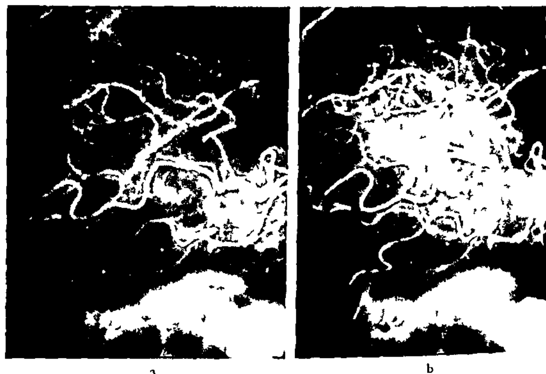


Fig 1 Case 1 Glioma involving the splenium of corpus callosum a) High CO_2 series A few abnormal vessels are seen above and below the distal part of the pericallosal artery b) Low CO_2 series There is a definite area of tumour vessels with an arterio venous shunt into the vein of Galen and straight sinus

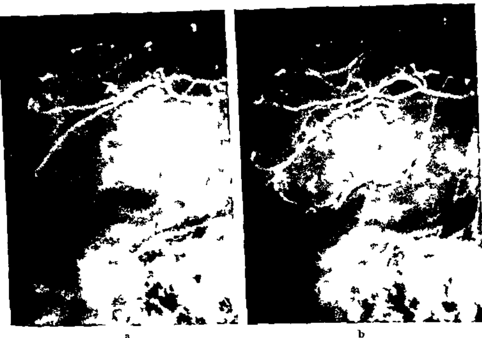
intracranial tumour and in twenty of these a tumour circulation was visible It will be seen from the Table that in 15 patients tumour vessels were better seen, or seen only, in the CO_2 series Fourteen of the patients had gliomas, with a better demonstration of tumour vessels in ten and similar improvement was seen in the low CO_2 series in five of the six patients with meningiomas

In the following case reports some of these changes are demonstrated The illustrative figures are matched for circulation phase and those marked (a) were obtained at a high CO_2 and those marked (b) at a low CO_2 in each case

Cases 4 and 5 demonstrate the better filling of the extracerebral arteries that occurs at a low CO_2 and which may be of value in the examination of patients with meningiomas

Case reports

Case 1 A male, aged 60 years complaining of tiredness and mental confusion for several months with more recent onset of headache and vomiting Examination revealed bilateral papilloedema a left homonymous haemianopia and sensory impairment of the left arm and leg with increased tendon reflexes on this side



a b

Fig 2 Case ? Temporal lobe gl oma a) High CO_2 series The tumour appears to be largely avascular b) Low CO_2 series There is an extensive tumour circulat on with early filling of a vein draining into the transverse s nus

At right common carotid angiography there was no di placement in the a p films In the lateral series taken at a high CO a few abnormal vessels were seen above and below the distal part of the pericallosal artery (Fig 1a) In the series taken at a low CO however there was a definite area of tumour vessels with an arterio-venous shunt into the vein of Galen and straight sinus (Fig 1b) This proved to be a glioma involving the splenium of the corpus callosum

Case ? A male of 36 years with a ix week history of dysphasia and more recent onset of right ided weakness On examination he was drowsy with a right hemiparesis and a right homonymous haemianopia but there was no evidence of papilloedema

At l ft common carotid angiography there was evidence of a temporal tumour In series a the tumour appeared to be largely avascular (Fig 2a) The series taken at a low CO showed a tumour circulation with early filling of a vein draining into the transverse sinus Fig b Biopsy confirmed that this was a temporal lobe glioma

Enhan ement of tumour circulation may also occur in the venous phase)

(e 3 A male of 51 years complaining of increasing weakness and paraesthesia of the r ght upper limb over a period of two years and with dysphasia and vomitin of more r ent on et Examination revealed bilateral papilloedema most marked on the left side and a ri ht facio-brachial weakness

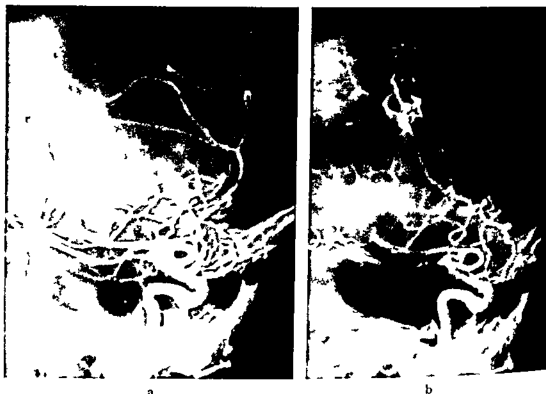


Fig 3 Case 4 Right posterior frontal convexity meningioma a) High CO series An enlarged anterior division of the middle meningeal artery is visible but is not well filled with the contrast medium b) Low CO_2 series The middle meningeal artery is enlarged and better filled there is already evidence of tumour circulation which is more easily visible due to vasoconstriction of the cerebral arteries

Left common carotid angiography was performed and apart from prolongation of the circulation time and reduction in calibre of the cerebral arteries in the films taken at a low CO_2 there was no difference between the two film series in the arterial phase During the venous phase however a definite tumour circulation was visible in the posterior frontal and anterior parietal region in the low CO_2 series This was not apparent on any film of the high CO_2 series The tumour proved at operation to be a necrotic grade III astrocytoma

Case 4 A male of 69 years with bilateral papilloedema and a right hemiparesis had evidence of a right frontal tumour at common carotid angiography An enlarged anterior division of the middle meningeal artery was visible in film series (a) but it was not well filled with contrast medium (Fig 3a) In film series (b) obtained at a low CO this artery was enlarged and better filled there was evidence of a tumour circulation which was more easily visible due to vasoconstriction of the cerebral arteries (Fig 3b)

Operation confirmed the angiographic diagnosis of a right frontal convexity meningioma

Case 5 A female of 53 years with mental deterioration headache vomiting and bilateral papilloedema, clearly had a subfrontal tumour at common carotid angiography In series (a) no abnormal vessels could be detected (Fig 4a) but in (b) an enlarged ethmoidal



Fig 4 Case 5 Olfactory groove meningioma a) High CO_2 series The fronto-polar artery is elevated but no abnormal vessels can be detected b) Low CO_2 series An enlarged ethmoidal branch of the ophthalmic artery supplies an area of abnormal vessels above the floor of the anterior fossa

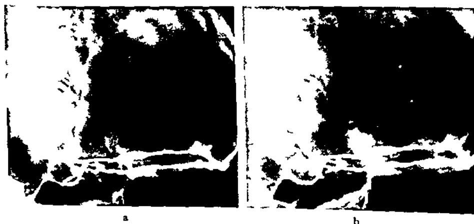


Fig 5 Case 5 a) High CO_2 series The tumour appears to be completely avascular b) Low CO_2 series The well circumscribed tumour circulation of an olfactory groove meningioma is clearly visible

branch of the ophthalmic artery supplied an area of abnormal vessels above the floor of the anterior fossa (Fig 4b) During the venous phase taken at a high CO the tumour appeared to be completely avascular (Fig 5a) In film series (b) the well circumscribed tumour circulation of an olfactory groove meningioma was clearly visible (Fig 5b)

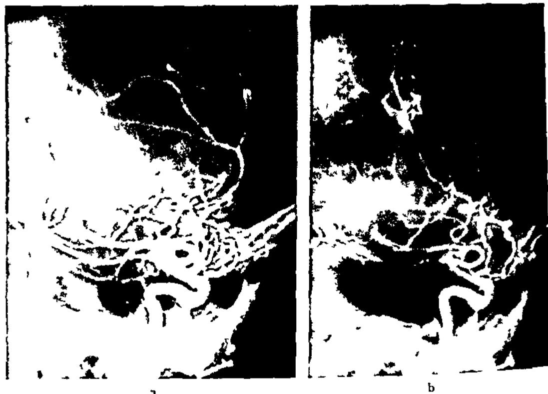


Fig. 3. Case 4. Right posterior frontal convexity meningioma. a) High CO_2 series. An enlarged anterior division of the middle meningeal artery is visible but is not well filled with the contrast medium. b) Low CO_2 series. The middle meningeal artery is enlarged and better filled; there is already evidence of tumour circulation which is more easily visible due to vasoconstriction of the cerebral arteries.

Left common carotid angiography was performed and apart from prolongation of the circulation time and reduction in calibre of the cerebral arteries in the films taken at a low CO_2 there was no difference between the two film series in the arterial phase. During the venous phase, however, a definite tumour circulation was visible in the posterior frontal and anterior parietal region in the low CO_2 series. This was not apparent on any film of the high CO_2 series. The tumour proved at operation to be a necrotic grade III astrocytoma.

Case 4. A male of 69 years with bilateral papilloedema and a right hemiparesis had evidence of a right frontal tumour at common carotid angiography. An enlarged anterior division of the middle meningeal artery was visible in film series (a) but it was not well filled with contrast medium (Fig. 3a). In film series (b) obtained at a low CO_2 this artery was enlarged and better filled; there was evidence of a tumour circulation, which was more easily visible due to vasoconstriction of the cerebral arteries (Fig. 3b).

Operation confirmed the angiographic diagnosis of a right frontal convexity meningioma.

Case 5. A female of 53 years with mental deterioration, headache, vomiting and bilateral papilloedema, clearly had a subfrontal tumour at common carotid angiography. In series (a) no abnormal vessels could be detected (Fig. 4a) but in (b) an enlarged ethmoidal

RESUMÉ

Les auteurs ont etudié l effet des modifications controlees de la pression du gaz carbonique à la fin de l expiration sur les vaisseaux cérebraux des malades atteints de tumeur intra cranienne Chez 15 malades sur 20 les vaisseaux tumoraux ont ete plus nettement visibles sous une faible pression de CO Les auteurs concluent que l angiographie cérebrale sous anesthesie generale avec une pression de CO faible est sans danger et peut améliorer le diagnostic de la tumeur

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Comments

The improved demonstration of meningiomas which receive blood supply from the extracerebral arteries seems to be due to more contrast medium entering these arteries, which are better filled and appear of wider calibre in the low CO_2 series, probably due to vasoconstriction and increased resistance of the cerebral arteries

The better demonstration of gliomas could have a similar explanation in that tumour vessels may fail to respond in a physiological manner to a low CO_2 whereas normal cerebral vessels are reduced in calibre This may result in deviation of blood and hence contrast medium into the tumour circulation

Conclusions

It is suggested on the evidence available that patients with intracranial tumours examined under a general anaesthetic should have their ventilation controlled to achieve a low arterial carbon dioxide tension This method of anaesthesia has for some time been the accepted technique for neurosurgical operations (FURNESS 1957) It is considered that its use should be extended to cerebral angiography, both for added safety in patients with raised intracranial pressure and for the possible improvement in the demonstration of a tumour circulation, compared with angiography performed under general anaesthesia with spontaneous respiration

It will be of interest to determine whether the radiologic changes shown in this study are apparent when comparing the effect of normal and low CO_2 levels

A further study on these lines is in progress

SUMMARY

In a study of the effect of controlled variation of the end expiratory carbon dioxide tension on the cerebral vessels of patients with intracranial tumours an improved demonstration of tumour vessels was observed at low CO_2 values in 15 out of 20 patients It is concluded that cerebral angiography under general anaesthesia at a low CO_2 tension is safe and may improve tumour diagnosis

ZUSAMMENFASSUNG

Bei einer Untersuchung des Effekts kontrollierter Variationen des endexpiratorischen Kohlendioxyddrucks auf die Gehirngefasse von Patienten mit intrakranialen Tumoren konnte eine verbesserte Darstellung der Tumorgefasse bei 15 von 20 Patienten bei niedrigen CO_2 Werten beobachtet werden Die Autoren ziehen die Folgerung dass die cerebrale Angiographie unter allgemeiner Narkose bei niedrigem CO_2 Druck sicher ist und die *Diagnostik* verbessern mag

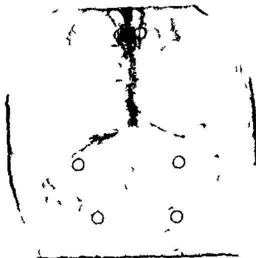


Fig 1 Indication of veins used in the study for estimation of the local circulation times in angiography of the vertebral artery occipital veins veins of the cerebellar hemisphere and of the cerebello-pontine angle

occipital veins the veins of the cerebellar hemisphere and the veins of the cerebello-pontine angle was estimated bilaterally (Fig 1) In this manner the local circulation times for the supra and infratentorial areas drained by these veins were obtained and the mean of these six regional circulation times were regarded as representative of the mean circulation time through the vertebral artery system

Results and Discussion

Both carotid and vertebral angiographies were performed in 39 cases The circulation times obtained by carotid angiography and estimated from the parietal veins (Greitz 1956) were plotted against the circulation times recorded at angiography of the vertebral artery and estimated from the occipital veins A weak but definite correlation could be established (Fig 2) The greatest differences between the two circulation times were observed in cases of tumour and in all the cases which had anesthesia If these two groups were excluded no difference greater than 1 second would have been recorded It also appeared as if anesthesia tended to prolong the vertebral circulation time in relation to the carotid circulation time

Further proof of the practicability of circulation time determinations by vertebral angiography are the results obtained by cerebral blood flow measurements after the injection of radio-active xenon into the vertebral artery When the CBF values obtained were plotted against the mean vertebral circulation times, the same correlation between the cerebral blood flow and the angiographic circulation

FROM THE DEPARTMENT OF NEURORADIOLOGY (DIRECTOR PROF T GREITZ), KARO LINSKA SJUKHUSET, STOCKHOLM, SWEDEN

EVALUATION OF CIRCULATION TIME IN ANGIOGRAPHY OF THE VERTEBRAL ARTERY

by

T GREITZ

This communication is directed to the value of the determination of infra tentorial and supratentorial circulation times as revealed in an investigation of a relatively large material

Method and Material The circulation time in angiography of the carotid artery is usually determined from a series of lateral films In vertebral angio graphy, however, the vessels of both sides overlap, and since 1964 the author has preferred the half axial a p projection

The usual program has been followed, i e 2 films/s for 6 seconds, 1 film/s for 4 seconds and 1 film every other second for 6 seconds Four milliliters of Uro grafin 60 % were manually injected in about one second, either through a needle directly inserted or through a catheter The ECG was also recorded

More than 500 patients have been examined in this way The present com munication is based on 23 cases regarded as normal, 67 cases with infra and supra tentorial tumors, ten of which were examined under general anesthesia, and a few cases without intracranial focal lesions

The circulation time was determined as the time interval between the max imum filling of the basilar artery and the local veins The maximum filling of the

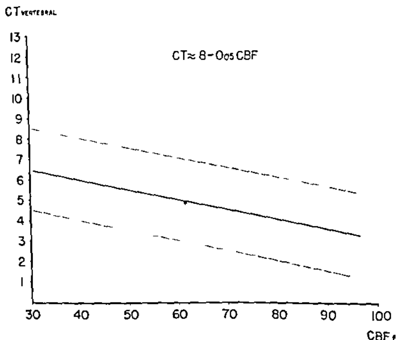


Fig 3 Correlation between mean vertebral circulation time (CT) given in seconds and the fast flow values for regional cerebral blood flow (CBF_f) through the vertebral artery system as determined with the xenon 133 technique according to Lassen—Ingvar The full line indicates regression of CT on CBF which in angiography of the carotid artery was approximately CT=8−0 5 CBF the broken lines indicate twice the residual standard deviation

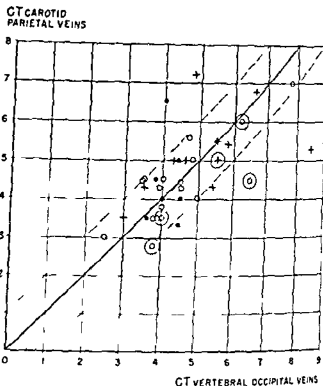
cases supratentorial cases infratentorial intra axial and infratentorial extra axial tumour cases (Fig 4)

In no case of the normal material was the difference between the supra and infratentorial circulation over half a second

In supratentorial tumours even when the cases examined during general anesthesia were disregarded no marked tendency for the supratentorial circulation time to be longer than the vertebral circulation time was observed In two cases however the difference between the supra and infratentorial circulation times exceeded one second

In infratentorial tumours extra axial as well as intra axial an obvious trend for the infratentorial circulation time to be longer than the supratentorial time existed however The infratentorial circulation time was over a second longer

Fig 2 Correlation between circulation times determined by angiography of the carotid artery (CT carotid) and those determined by angiography of the vertebral artery (CT vertebral) in 39 cases The circulation times were estimated as the time intervals between maximum filling of the carotid siphon and the parietal veins and between the basilar artery and the occipital veins respectively All the circulation times are given in seconds A full line indicates that the values are equal values within broken lines do not differ more than one second Symbols o indicate normal cases and cases without focal lesions ● tumour cases without papilloedema + tumour cases with papilloedema and encircled symbols indicate cases examined under general anesthesia



time as was found after injection into the carotid artery (CRONQVIST & GREITZ, to be published) seemed to exist after injection into the vertebral artery (Fig 3)

The mean local circulation times in the normal material on the injected side were 3 68 seconds for the occipital veins 3 57 seconds for the cerebellar hemispheric veins and 3 70 seconds for the veins of the cerebello pontine angle On the non injected side the corresponding values were 3 58, 3 57 and 3 50 seconds, respectively The mean values were thus slightly higher on the injected side, but all were in the neighbourhood of 3 5 to 3 7 seconds The mean circulation time for all groups of veins was 3 60 seconds, which may be regarded as the normal mean circulation time It has however been found practical and justifiable to use the same normal mean circulation time as in carotid angiography (GREITZ 1968), i e 3 5 seconds, with a standard deviation of 0 5 seconds Out of 57 tumour cases examined without anesthesia, twenty five had papilloedema and a mean circulation time of 5 7 seconds Thirty two cases without papilloedema had a mean circulation time of 4 3 seconds

In order to evaluate possible local circulatory disturbances the mean supratentorial circulation times as determined from the occipital veins were compared with the mean infratentorial circulation times in four different materials normal

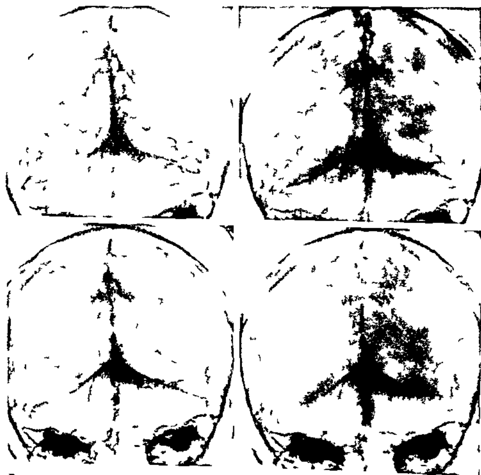


Fig 5 Cerebellar tumour The veins of the posterior fossa fill and empty later than the supratentorial occipital veins

influence the circulation on the ipsilateral side As is indicated by Fig 7 the difference between the two sides was never over one second In four cases of infratentorial tumour however the circulation time on the affected side was more than a second longer than on the other side The same comparison was also mad for the supratentorial circulation in a material of supratentorial tumours (Fig 8) The mean circulation time was longer on the affected than on the contralateral side but only in one case was the difference greater than in the normal material (Figs 8 and 9)

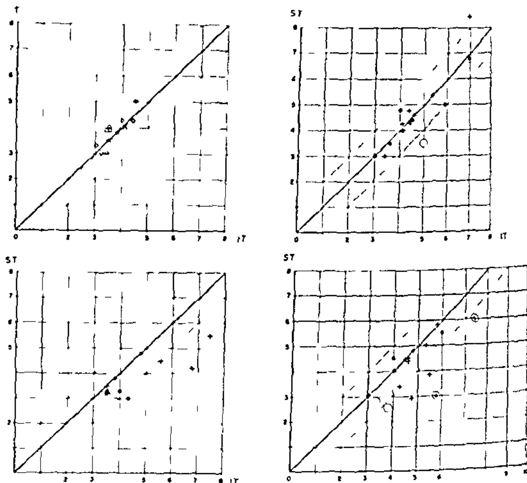
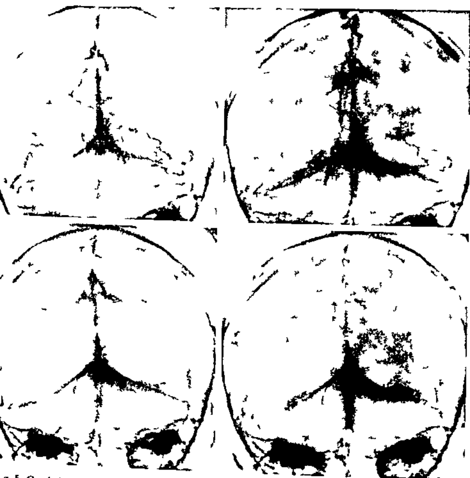


Fig 4 Graphic demonstration of the relationship between supratentorial (ST) and *infratentorial circulation time* (IT) in four different materials top left normal cases top right supratentorial tumours, bottom left extra axial infratentorial tumours bottom right intra axial infratentorial tumours There is retardation of the infratentorial circulation in cases of posterior fossa tumour

than the supratentorial circulation time in twelve out of thirty five cases The delayed circulation within the posterior fossa was sometimes obvious from mere inspection of a series of films in the venous phase, the supratentorial veins commencing to fill and becoming completely filled before the infratentorial veins This resulted in an empty appearance of the posterior fossa in the capillary and early venous phases (Fig 5) The subtraction technique may prove helpful in demonstrating this type of circulation (Fig 6)

The circulation times on the tumour side and the contralateral side may be compared in a p projections A comparison was made of the injected and the opposite sides in a normal control material since of course the injection ma



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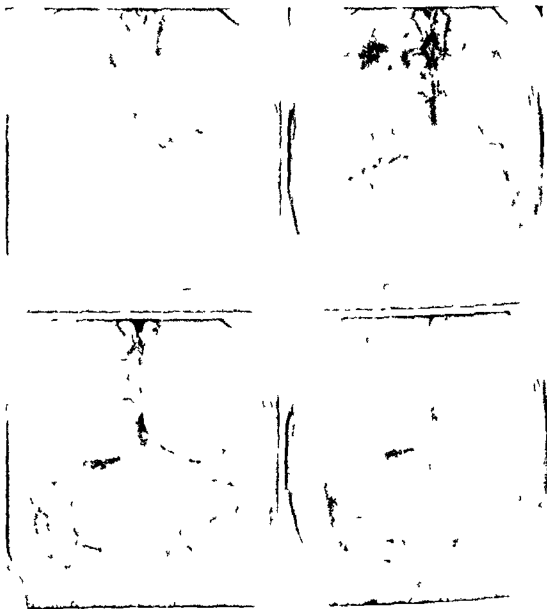
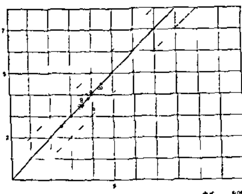
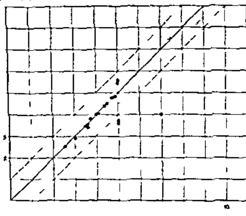


Fig 6 Cerebellar tumour subtraction technique Empty appearance of the posterior fossa in the early venous phase There is a difference in the filling time of the supra and infra tentorial veins

Conclusions

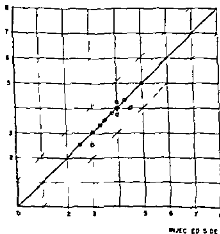
The investigation indicates that vertebral angiography may be used for the study of infratentorial and supratentorial circulation times and that regional changes in the times may occur These changes are seldom of such a magnitude that they by themselves permit of a more detailed diagnosis of a posterior fossa

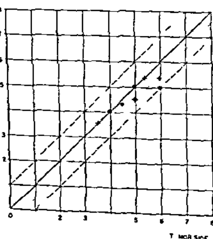




a b

Fig 7 a) Normal cases Relationship between infratentorial circulation times on the injected and contralateral s des the tendency to prolongation of the time on the injected s de is hardly noticeable with a sati factory injection b) Infratentorial tumours Correlation between the infra t ntorial c rculation times on the affected and opposite sides definite prolongation of the times in four cases





a b

F g 8 a) Normal cases. Correlation between supratentorial circulation times on the injected and contralateral s des. b) Supratentorial tumours. A tendency towards prolonged supraten torial circulation on the affected side is evident in the whole material

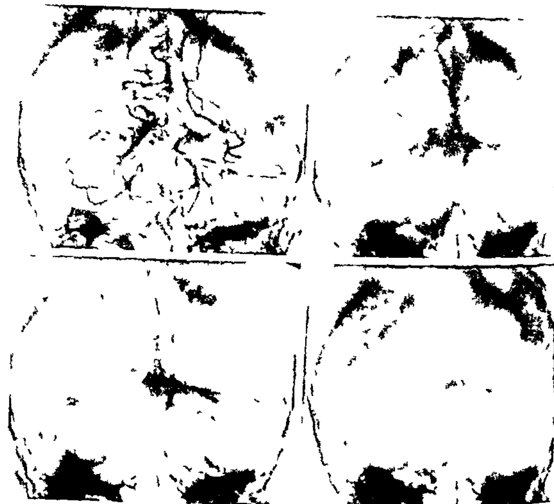


Fig. 9. Left occipital glioma. The filling and emptying of the occipital veins on the affected as compared to the contralateral side are delayed.

tumour. A definite prolongation in the general circulation time is frequent enough to suggest its routine use in vertebral angiography.

Acknowledgements

This investigation was supported by grants from the foundation Gustav och Thyra Svenssons Minne and Riksforeningen mot Cancer.

SUMMARY

General and local disturbances in the cerebral circulation were studied by serial angiography of the vertebral artery with half axial a.p. projections. The circulation times for the right and left sides as well as the infra- and supratentorial circulation times were compared. The mean normal circulation time proved to be approximately the same as in carotid angiography, i.e. 3.5 seconds.

ZUSAMMENFASSUNG

Allgemeine und lokale Storungen der cerebralen Blutzirkulation wurden in den halb axialen anterio-posterioren Aufnahmen bei Serienangiographie der Arteria vertebralis studiert Vergleiche zwischen der Zirkulationszeit der linken und rechten Seiten sowie zwischen der infra und supra tentoriellen Zirkulationszeit wurden vorgenommen Die durchschnittliche Zirkulationszeit war ungefahr dieselbe wie bei Karotisangiographie d h 3 5 Sekunden

RÉSUMÉ

L auteur a etudié les perturbations generales et locales de la circulation cerebrale au moyen d angiographies en serie de l artère vertebrale dans l incidence semi axiale (fronto ous occipitale) Il a compare les temps de circulation du coté droit et du cote gauche ainsi que les temps de circulation infra et supra tentoriel Le temps moyen normal de circulation est approximativement le meme qu en angiographie carotidienne c est a dire 3 5 secondes

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OCCULT HYDROCEPHALUS DUE TO ECTASIA OF THE BASILAR ARTERY

by

T. GREITZ, K. EKBOM, E. KUGELBERG and A. BREIG

Hydrocephalus in the adult has recently attracted considerable attention. A great number of causes have been described, among which aqueduct stenosis and subarachnoid haemorrhage are probably the most common. Within a short period of time the authors have observed five adults with clinical signs considered characteristic of hydrocephalus, consisting in disabling progressive dementia, and a peculiar walk best described as apraxia of gait. All five cases had high blood pressure. Details about this syndrome have been reported elsewhere (BREIG et coll. 1967).

Radiologic observations. Moderate to considerable dilatation of the lateral ventricles and deformity of the third ventricle, indicative of ectasia of the basilar artery, were evident at encephalography (GREITZ & LOFSTEDT 1954, DETTORI et coll. 1966). The deformity usually consisted not only in an indentation into the floor of the third ventricle but also in a forward upward dislocation of the anterior wall (Fig. 1). There was dilatation of the basal cisterns in which the enlarged basilar artery could be seen. The change in the artery was confirmed by vertebral angiography in all five cases.

Dilatation of the lateral ventricles in conjunction with an ectatic basilar



Fig. 1. Hydrocephalus and deformity of the third ventricle in four cases of basilar artery ectasia. No obvious correlation between the degree of hydrocephalus and the deformity.

artery causing third ventricle deformity has earlier been attributed to atrophy. It was however observed that air in only small quantities passed beyond the dilated basal cisterns almost exclusively through the Sylvian fissures and through often widened sulci adjacent to the interhemispheric fissure. The air could thus be said to follow the widened cerebrospinal fluid pathways. *No or*

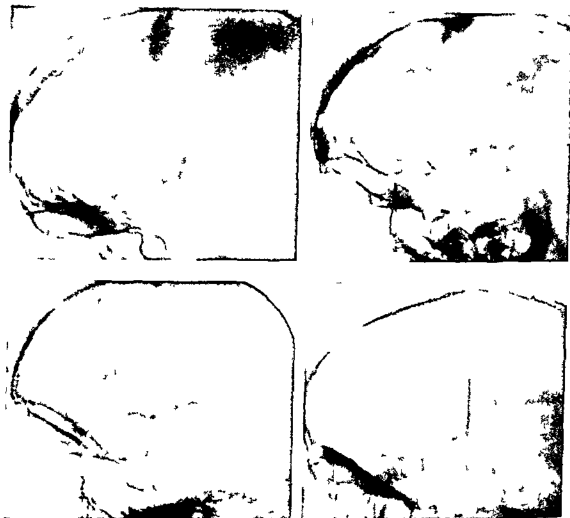


Fig 2 Four cases of hydrocephalus due to an ectatic basilar artery The air in the sulci of the frontal and temporal regions is located in the interhemispheric and Sylvian fissures (cf fig 3)

almost no air was present over the convexities (Figs 2 and 3) As the encephalographic findings seemed to indicate an obstruction to the cerebrospinal fluid circulation, gammacisternography with RIHSA by the Di Chiro method was carried out in two cases and indicated a slow passage of RIHSA to the convexities (Fig 4) In one case the activity changes were checked by external counting The activity over the convexity never exceeded the activity over the basal cisterns (Fig 5) In three of the cases the cerebral blood flow (CBF) was studied with the ^{133}Xe clearance method of Lassen & Ingvar (1963) and was found to be significantly decreased Postoperative determination of the CBF was made in one case and revealed a definite increase in flow

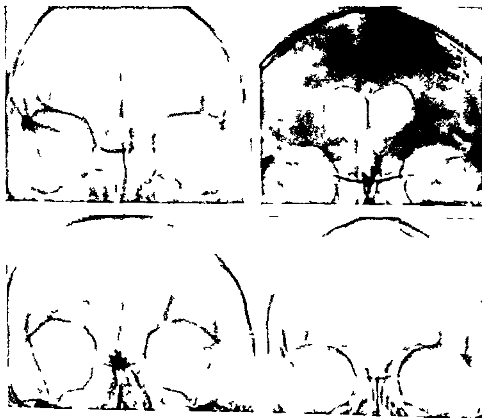


Fig 3 Same cases as in fig 2 The case illustrated in the lower left figure has a minimal amount of air over the left convexity Asymmetric ventricular dilatation is present in this case In the other three cases air filled sulci are seen only in the interhemispheric and Sylvian fissures these are cases of symmetric hydrocephalus

Discussion

It is now well established that hydrocephalus may be present and be clinically symptomatic without the intraventricular pressure being elevated (HAKIM & ADAMS 1965 ADAMS et coll 1965) Two of the present cases which were subjected to operation had intraventricular and lumbar CSF pressures within normal limits The pulse synchronous intraventricular pressure variations were however higher in relation to the pressure variations in the lumbar region than in two cases of hydrocephalus without ectasia This may indicate that the pulsations from the ectatic artery are transmitted to the ventricular system

Two out of the three cases operated upon presented definite clinical improve



Fig 4 RIHSA cisternography carried out at 3 8 24 and 48 hours reveals slow cerebrospinal fluid circulation The activity has not reached the convexity at 48 hours most of it remaining in the interhemispheric and Sylvian fissures a small fraction has probably entered the ventricular system

ment following the shunting procedure There appears to be little doubt that the ventricular dilatation should be considered as hydrocephalus of the low pressure type and that its association with ectasia of the basilar artery cannot be considered a coincidence Ectatic cerebral arteries may produce hydrocephalus in three different ways by direct compression of the CSF pathways e g by deforming the third ventricle, by increasing the expansible force of the undamped pulse wave to the ventricular walls which might be due either to ectatic changes in the choroid arteries or arteries adjacent to the ventricular system or finally by bleeding

Subarachnoid haemorrhage is not unlikely with ectatic arteries which are known to have multiple defects in their elastic membranes there was no clinical evidence of this in the present cases Impairment of the CSF flow might have been brought about by a combination of both anatomical and functional obstruction Once the ventricles have become dilated they may remain distended by the normal CSF pressure in accord with Pascal s law (ADAMS et coll 1965) The displacement of the cortex towards the calvarium, which was present in the cases both at angiography and operation, compresses the subarachnoid space and may hinder the CSF circulation and bring about a vicious circle in the development of hydrocephalus

Stretching of nerve fibres has been considered to be the cause of the signs in

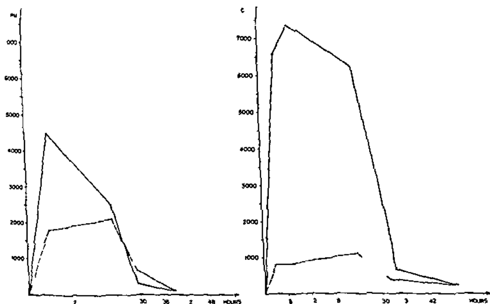


Fig 5 External counting of activity over the basal cisterns (full lines) and convexity (hatched lines) after intrathecal injection of 90 microcurie RIHSA in a normal case (left) and in a case of ectasia of the basilar artery with hydrocephalus (right) The activity recorded from the convexity is lower in the latter than in the normal case relatively as well as absolutely and never exceeds that recorded over the basal cisterns

hydrocephalus (YAKOVLEV 1947) Another more plausible explanation would be the increase in cerebral blood flow which may follow a shunting procedure This assumption is supported by the fact that one of the cases, in which pre and post operative determinations of the CBF were made had a significant increase in blood flow after operation This case presented marked clinical improvement

As cases of occult hydrocephalus may be much improved by a relatively simple procedure it is important that radiologists recognize hydrocephalus in basilar ectasia as such and do not make an erroneous diagnosis of atrophy Generalized ectasia is a common phenomenon and may well be a common cause of presenile dementia.

Acknowledgements

This investigation was supported by a grant from the Medical Research Council of the Swedish Life Offices



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SCISSURE DE SYLVIUS ET SES REPERES ARTERIOGRAPHIQUES

par

JEAN FRANÇOIS GUYOT et JACQUES PHILIPPON

Reperer la scissure de Sylvius est une necessite autant pour le neuro-radiologue que pour le neuro chirurgien et nombreux sont les systemes de reference deja utilises Pour notre part nous envisagerons sur les arteriographies de profil un ensemble de reperes permettant de situer la scissure de Sylvius par rapport au contour osseux de la fosse temporale Les anatomistes classiques ont precise avec beaucoup de soin comment on pouvait topographier la scissure de Sylvius par rapport a la boite cranienne TESTUT & LATARJET dans leur Traite d Anatomie indiquent que la vallee sylvienne se projette selon une ligne allant du nasion au lambda et occupe une longueur de 8 a 9 centimetres ce sont egalement les reperes de Poirier

TAYLOR & HAUGHTON utilisant des radiographies apres avoir marque les differentes structures avec des fils metalliques proposent un systeme de reference tres utilise mais d une complexite certaine pour ces auteurs la scissure de Sylvius est un peu plus inclinee en bas et en avant que la ligne nasion lambda

Les neuro-radiologues ont eu avec l arteriographie et l encephalographie l occasion de preciser les reperes des anatomistes avec l avantage de le faire in vivo

Sur l arteriographie carotidienne les arteres sylviennes dessinent les differents

SUMMARY

Five cases with high blood pressure and clinical signs and symptoms consistent with low pressure hydrocephalus were found to have third ventricle deformity caused by an ectatic basilar artery New radiologic aspects of this deformity are described and the opinion is expressed that the associated ventricular dilatation is mainly due to hydrocephalus and not, or to a lesser extent to cerebral atrophy

ZUSAMMENFASSUNG

Bei einem Material von funf Fallen mit hohem Blutdruck und klinischen Erscheinungen von Hydrocephalus mit Normaldruck zeigte sich eine Deformation des dritten Ventrikels die offenbar durch eine Erweiterung der Basilararterie hervorgerufen war Neue radiologische Zeichen dieser Deformität werden besprochen Man darf annehmen dass die zugehorige Erweiterung des dritten Ventrikels hauptsächlich dem Hydrocephalus zugesprochen werden muss und nicht oder nur im geringen Masse der cerebralen Atrophie

RÉSUMÉ

Dans cinq cas d hypertension arterielle associee a des signes cliniques objectifs et subjectifs d hydrocephalie sans hypertension intracranienne les auteurs ont trouve une deformation du troisieme ventricule causee par une ectasie du tronc basilaire Ils decrivent les signes radiologiques inédits de cette deformation et expriment l opinion que la dilatation ventriculaire associée est principalement due a l hydrocephalie et non ou seulement dans une moindre mesure a l atrophie cerebrale

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l arriere plus souvent elles convergent vers l avant lorsque le crane est court et la saillie du rocher tres accentuee

Aucune ligne de repere n est parfaite et celle ci ne veut pas echapper a la regle elle represente cependant une ligne moyenne qui nous a rendu service dans la pratique de tous les jours et a en outre l avantage de la simplicite

RÉSUMÉ

Les branche de l artere sylvienne en contournant les opercules pour gagner la convexite form nt une serie de boucles alignees dans le sens de la scissure de Sylvius La ligne ainsi formee e t reperee de la façon suivante par rapport au contour osseux de la fosse temporale elle prolonge en arriere l arete sphenoidale elle est parallele au plancher de la fosse temporale elle commence a l aplomb du tuberculum sellae et elle se termine a l aplomb de l extremite posterieure du rocher

SUMMARY

The branches of the sylvian artery when rounding the opercula in the direction of the cerebral convexity form a eries of loops aligned with the sylvian fissure The line can be identified by its relation to the bony outline of the temporal fossa it extends the line of the sphenoid wing backwards and runs parallel to the floor of the temporal fo sa it begins at a point formed by the vertical to tuberculum sellae and ends at the point of a vertical from the posterior extremity of the petrous bone

ZUSAMMENFASSUNG

Die Ae te der Arteria cerebralis media wenn sie die Operkula in Richtung der Konvexitat umlaufen bilden eine Reihe von Kurven langs der Fissura cerebri lateralis Die Linie kann in ihrer Beziehung zur knochernen Kontour der Fo sa temporalis identifiziert werden Sie verlauft in Fortsetzung der Linie des Keilbeinflugels parallel zum Boden der Fossa t mporalis sie fan t beim Vertikal zum Tuberculum sellae an und endet beim Vertikal zum hinteren Ende des Felsenbeines

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formée donne la hauteur anatomique du pôle temporal et donne donc en même temps le niveau de l'entrée de la vallée sylvienne ; cette hauteur est très variable d'un individu à l'autre, selon le développement de la fosse temporale, elle est relativement grande chez l'enfant.

Ces repères en direction et en hauteur de la scissure de Sylvius sont une conséquence logique de l'anatomie du lobe temporal et de sa loge osseuse.

Limites antérieure et postérieure. Contrairement aux repères précédents, ceux que nous proposons pour les limites antérieure et postérieure de la scissure de Sylvius ne sont qu'artificielles. En avant, la scissure de Sylvius coupe le bord du triangle insulaire à l'aplomb du tuberculum sellae. En arrière, la scissure de Sylvius se confond avec l'angle postérieur du triangle insulaire à l'aplomb de l'extrémité postérieure du rocher.

Discussion

Des difficultés de repérage sont possibles et peuvent tenir soit au malade soit à la technique.

1. Si les clichés ne sont pas en profil strict mais tête inclinée ou tournée, les contours des deux fosses temporales sont nettement décalés l'un par rapport à l'autre, et le repérage, même après corrections, n'est plus que très approximatif.

2. Si le dessin osseux de la fosse temporale n'est pas net, on peut s'aider du temps veineux qui, en injectant les veines sylviennes et le sinus latéral, souligne en quelque sorte les structures osseuses (ptéryon, point déclive et extrémité postérieure du rocher).

3. Il faut insister davantage sur les variations des artères elles-mêmes.

Artères anormalement longues et flexueuses : il est alors difficile de savoir en quel point précis elles contournent les opercules et donc de construire la ligne sylvienne.

Les artères temporales contournent l'opercule inférieur sans y rencontrer de sillon. Elles sont donc correctement alignées selon le sens de la scissure de Sylvius en formant une légère courbe d'ensemble à concavité inférieure ; mais, l'artère temporale antérieure est souvent difficile à voir sur les temps artériels précoces en raison des superpositions.

Les artères sus-sylviennes sont alignées avec moins de régularité car les deux branches antérieures quittent la vallée sylvienne par ses prolongements supérieurs horizontal et vertical, ainsi, les deux premières courbes peuvent se situer à un niveau nettement plus élevé que les suivantes.

4. Le parallélisme est correct à 10° près entre le plancher de la fosse temporale et la scissure de Sylvius, ces deux lignes convergent exceptionnellement vers

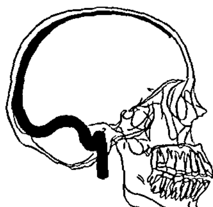


Fig 1

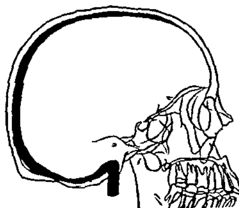


Fig 2

Fig 1 Normal sinus configuration The lateral sinus sweeps horizontally from the torcular Herophili to the lateral end of the petrous pyramid it has an anterosuperior convexity

Fig 2 Arnold—Chiari type of sinus (associated with myelomeningocele) The torcular Herophili is located near the posterior margin of the foramen magnum follows the margin of the foramen forward and has a postero-inferior convexity

(Fig 2) The torcular Herophili was low and lay near the posterior margin of the foramen magnum The posterior part of the lateral sinus did not take a horizontal course across the occipital squama but followed closely the margin of the foramen magnum The convexity of the sinus was directed posterior inferiorly It did not reach the lateral aspect of the petrous pyramid and the sigmoid sinus was almost entirely lacking One child with myelomeningocele appeared to exhibit an intermediate type of sinus configuration having a high lateral sinus on one side and a low lying sinus on the other

A composite view of the typical appearances of the two groups as seen in frontal projection (Fig 3) shows that in the group without myelomeningocele the convexity of the sinus is directed outward whereas in the myelomeningocele group it is directed inferomedially

One child in the myelomeningocele group died approximately one year after his first admission At autopsy the lateral attachment of the tentorium cerebelli was seen close to the margin of the foramen magnum (Fig 4a) Parts of the brain stem and cerebellum were seen above the abnormally low tentorial notch After removal of the brain stem and cerebellum the extremely low position of the apex of the tentorium the smallness of the posterior fossa and the abnormal arrangement of the lateral tentorial attachments were evident (Fig 4b) Since the lateral sinus lies at the attachment of the tentorium to the inner table of the

FROM THE DEPARTMENTS OF RADIOLOGY AND NEUROSURGERY, UNIVERSITY OF KENTUCKY MEDICAL CENTER, LEXINGTON, KENTUCKY, U S A

ANGIOGRAPHIC FINDINGS IN CONGENITAL INFANTILE HYDROCEPHALUS

by

J HOWIESON and H NORRELL

Radiographic depiction of the dural venous sinuses, originally described by FRENCKNER in 1934, has seldom been used in the investigation of hydrocephalus The infrequency of its use has delayed adequate description of the range of normal and abnormal appearances and thereby limited the accuracy of radiographic interpretation

This preliminary report presents the results of an investigation of 28 hydrocephalic infants Percutaneous puncture of the sagittal sinus was performed at the posterior margin of the anterior fontanel Manual injection of 4 ml meglucamine iothalamate 60 % was followed by a radiographic 5 film sequence at a rate of one exposure every 2 seconds One lateral sinus was filled in ten of the infants and bilateral filling occurred in the remainder

Two distinct lateral sinus configurations were observed

The first occurred in infants without myelomeningocele (Fig 1) In this group, the torcular Herophili was in normal position at the internal occipital protuberance near the posterior pole of the cranium and approximately half way between the lambda and the posterior lip of the foramen magnum The posterior part of the lateral sinus took a more or less horizontal course across the inner aspect of the occipital squama The middle third of the lateral sinus was convex anterosuperiorly The sigmoid sinus and jugular bulb were normally placed and in only one case was there equivocal evidence of constriction

The second group consisted of 11 children with myelomeningocele In this group, the lateral and sigmoid sinuses had an entirely different configuration

This work was in part supported by the Easter Seal Research Foundation

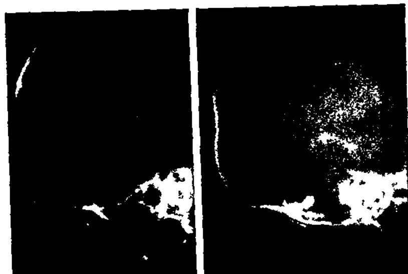


Fig 5 Lateral views with cerebral spinal flu d pressure elevated to 600 mm of water (left) and at 100 mm of water (right) showing the collateral venous drainage during increased pressure

order to compare the appearance of the dural sinuses at normal pressure (approximately 100 mm of water) with the appearance at elevated CSFP (approx imately 600 mm of water) The raised pressure was produced by infusion of saline into one lateral ventricle using a constant rate infusion pump while monitoring the pressure in the opposite lateral ventricle

Four of these children had myelomeningocele In all four basal compression of the lateral sinuses producing partial obstruction was demonstrated when the pre sure was elevated to 600 mm of water (Fig 5a) In the lateral projection the appearance of the sinuses during low pressure can be compared with that at high pressure in the same patient The drainage of the sinuses by collateral channels involving parietal occipital and mastoid emissary veins should be noted Collateral venous drainage with raised CSF pressure was also demonstrated in four children not having myelomeningocele but the number and size of col lateral channels was smaller than in the myelomeningocele group This finding indicates that some degree of venous obstruction results from raised CSF pressure in hydrocephalics with as well as without myelomeningocele but the degree of obstruction is greater in the myelomeningocele group

The sagittal sinus emptying time was studied in 13 children With the CSF pres ure in the normal range the sagittal sinus emptying was two seconds or less in nine of the children The emptying time was six to eight seconds in the re



Fig 3 Ap projections of (left) the normal type of sinus configuration and (right) the Arnold—Chiari type Both configurations are shown for comparison in the diagram

skull, it appears that Arnold—Chiari malformation, which accompanies myelomeningocele in approximately 95 % of cases (RUSSEL & DONALD 1935), accounts for the abnormality of the dural venous sinuses which we have demonstrated In hydrocephalus not associated with myelomeningocele and, therefore, not associated with Arnold—Chiari malformation, the dural sinuses had a normal configuration

In 12 children, the injection of contrast medium was repeated with the cerebrospinal fluid pressure (CSFP) artificially elevated to 600 mm of water in



Fig 4 a) Pathologic specimen showing parts of cerebellum and brain stem above the abnormally low tentorial notch b) After removal of the brain the low position of the tentorium and the smallness of the posterior fossa are evident The correlation between abnormal dural attachments and the abnormal radiographic appearance of the dural sinuses is obvious

FROM THE DEPARTMENT OF RADIOLOGY OF THE MOUNT SINAI SCHOOL OF MEDICINE AND THE MOUNT SINAI HOSPITAL, NEW YORK U S A

ANGIOGRAPHIC ANATOMY OF THE INFERIOR VERMIAN VEIN OF THE CEREBELLUM

by

Y P Huang B S Wolf and T Okudera

The presence of a paramedian vein running longitudinally on the surface of the inferior vermis is well known although few details of the anatomical course of this vein and its tributaries have been described This vein has been designated as the median inferior cerebellar vein (2 3, 5 6 10) or 'middle inferior cerebellar vein (9) The term inferior vermian vein however appears most convenient since this vessel is intimately related to the inferior vermis and is a counterpart of the better known superior vermian vein (7)

Anatomy When the cerebellum is viewed from behind and below there is a deep vertical cleft between the hemispheres known as the posterior cerebellar notch (Fig 2) The floor of the notch is formed by the inferior vermis and the side walls by the medial or falcial aspects (the surface facing the falx cerebelli) of the cerebellar hemisphere on each side The inferior vermis is demarcated laterally from the hemisphere by the paired inferior paravermian (or vallecular) sulci The portions of the vermis in the depth of the posterior cerebellar notch are from above downward and forward the posterior margins of the declive folium tuber pyramid uvula and nodulus. The hemispheric portions of the cerebellum forming the side walls are the pos erior medial portions of the quadran

maining four, of whom two had myelomeningocele When the CSF pressure was raised to 600 mm of water, an emptying time of eight seconds or more was noted in all four children with myelomeningocele No similar increase in the emptying time was observed in the patients without myelomeningocele

Conclusions

Contrast examination of the dural sinuses can be used to demonstrate the abnormal tentorial attachments associated with Arnold—Chiari malformation The information gained by such studies has helped to explain inter relationships between CSF pressure and venous pressure in hydrocephalic infants (MEGISON, NORELL & WILSON 1967) We have not, however, demonstrated findings which would justify the use of sinography in routine clinical investigation of hydrocephalic patients with or without myelomeningocele

SUMMARY

The dural venous sinuses were examined in 28 hydrocephalic children In all the children who had myelomeningocele the sinus configuration was abnormal and was interpreted as Arnold—Chiari malformation Raised intracranial pressure in these children produced an obstruction of the dural sinuses near their exit from the skull resulting in prolonged emptying *time and collateral venous drainage*

ZUSAMMENFASSUNG

Die Duralvenensinus wurden in 28 Kindern mit Hydrocephalus untersucht *In allen Kin*dern mit Myelomeningocele wurde eine atypische Sinuskonfiguration radiographisch demonstriert und als Arnold—Chiari Missbildung interpretiert Bei Erhohung des intrakraniellen Druckes in diesen Kindern wurde Obstruktion der duralen Sinus in der Nähe ihres Austritts aus dem Schädel observiert dies hatte eine andauernde Entleerungszeit und kollaterale Venendrainage zur Folge

RÉSUMÉ

Les auteurs ont examiné les sinus veineux duraux chez 28 enfants hydrocephales Tous les enfants atteints de myeloméningocele ont des sinus en situation anormale ce qui nous paraît indiquer une malformation d Arnold—Chiari L hypertension intracranienne cause chez ces enfants une obstruction des sinus duraux près de leur sortie du crane, occasionnant un temps d evacuation prolongé et un drainage veineux collatéral

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FROM THE DEPARTMENT OF RADIOLOGY OF THE MOUNT SINAI SCHOOL OF MEDICINE
AND THE MOUNT SINAI HOSPITAL NEW YORK, U S A

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The presence of a paramedian vein running longitudinally on the surface of the inferior vermis is well known although few details of the anatomical course of this vein and its tributaries have been described This vein has been designated as the median inferior cerebellar vein (2 3 5 6 10) or middle inferior cerebellar vein (9) The term inferior vermian vein however appears most convenient since this vessel is intimately related to the inferior vermis and is a counterpart of the better known superior vermian vein (7)

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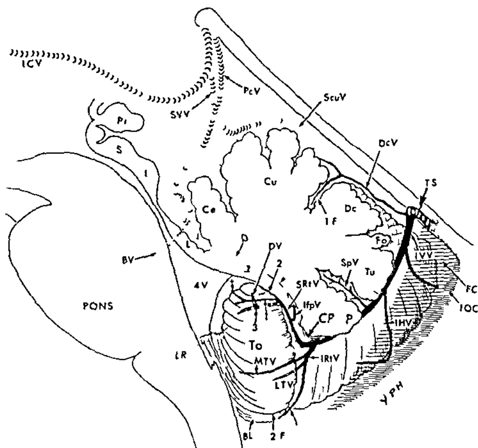


Fig 1 Anatomical relationships of the inferior vermian vein Midsagittal section of the brain stem and cerebellum The nodulus uvula and inferior portion of the pyramid have been removed to expose the vermian aspect of the cerebellar tonsil and the retrotonsillar space The attachment of the removed portion of the inferior vermis to the hemisphere is finely shaded (arrowheads) The aqueduct and fourth ventricle including its lateral and posterior superior recesses are uniformly shaded

The labeled structures (labels arranged alphabetically) include the ansoparamedian fissure (ApF) biventral lobule (BI) brachial vein (BV) central lobule (Ce) culmen (Cu) parenchymal vein (D) declive (Dc) declival vein (DcV) dentate vein (DV) falx cerebelli (FC horizontally shaded) folium (Fo) great horizontal fissure (GHF) inferior colliculus (I) intrabiventral fissure (IbF) internal cerebral vein (ICV) infrapyramidal vein (IfpV) inferior hemispheric vein (IHV) internal occipital crest (IOC horizontally shaded) inferior retrotonsillar vein (IRtV) inferior semilunar lobule (ISL) inferior vermian vein (IVV) lateral recess (LR) lateral tonsillar vein (LTV) medial tonsillar vein (MTV) pyramid (P) prebiventral fissure (PbF) precentral cerebellar vein (PcV) pineal gland (Pi) superior colliculus (S) supraculminate vein (ScuV) suprapyramidal vein (SpV) superior retrotonsillar vein (SRtV) superior semilunar lobule (SSL) superior vermian vein (SVV) tonsil (To) tentorial sinus (TS) tuber (Tu) uvula (U) supratonsillar tributaries (1 2 3) of the superior retrotonsillar vein primary and secondary fissures (1 F 2 F) and fourth ventricle (4V)

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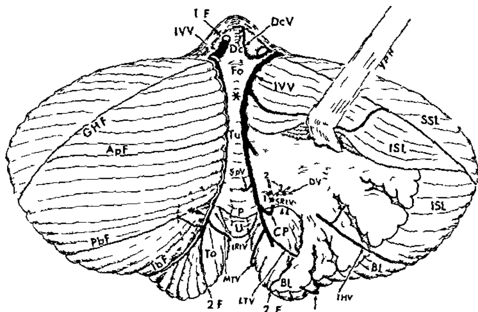


Fig 9 Posterior view of the cerebellum On the right side portions of the inferior semilunar lobule (ISL) and biventral lobule (BL) have been removed in order *to expose the lateral* extension of the copula pyramidis (unlabeled double arrowheads) and the posterior and lateral aspects of the cerebellar tonsil The mo t posterior point of the vermis is indicated by an asteri k (*) A characteristic angle is formed in the course of the *superior retrotonsillar vein* SRtV) at the inferior margin of the copula the copular point (CP) On the left side the inferior retrotonsillar stem runs in the tonsillob ventral notch (⟷) and receives tonsillar and biventral lobule tributaries Structures labeled as in fig 1

Fig 1 (Continuation of legend p 328)

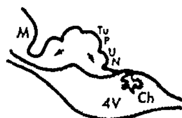
The inferio ermian vein (IVV) is formed by the union of the superior retrotonsillar vein (SRtV) and the inferior retrotons llar vein (IRtV) at the level of the copula pyramidis (CP)

The superior retrotons llar vein runs downward and backward in the retrotonsillar space and joins th inferio ermian vein with a characteristic infer orly convex curve corresponding to the opula py amidis A vein characterist cally located posterior to the superior retrotonsillar v n runs in the infrapyramidal portion of the se ondary *fi s re (IIpV)*

The *inferior* retrotons llar vein recei es tributaries from the medial surface of the cerebellar tonsil (MTV) from th lateral surface of the cerebellar tonsil (LTV) and from the *inferior* surface of the bi ntral lobul (*unlabeled arrow*)

Tribut ries drain ng into the inferior vermian vein include a vein arising in the supra pyramid l f ssure (SpV) veins from the inferior surface of the *cerebellum (IHV)* and declival vein (DcV)

The nferior ermian ein drains into the straight sinus often indirectly through a tentorial sinus (TS)



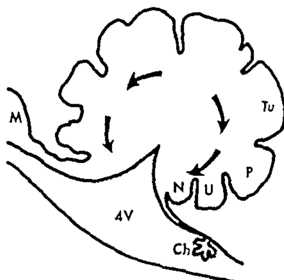


Fig 3 Diagrammatic representation of the cerebellum *showing the rotation of the* vermis and hemispheres during embryological development Mid sagittal section in an early (upper diagram) and a later stage (lower diagram) of development Labeled structures include the choroid plexus (Ch) of the 4th ventricle mesencephalon (M) nodulus (N) pyramid (P) tuber (Tu) uvula (U) and 4th ventricle (4V) The *originally caudally located nodulus (N) be*comes displaced downward forward and upward

gular lobules, the superior and inferior semilunar lobules, the biventral lobules and the cerebellar tonsils (Fig 2) The declive is separated from the culmen anteriorly by the primary fissure, and from the folium posteriorly by *the post clival fissure The fissure between the folium and the tuber is the* vermian portion of the great horizontal fissure The tuber is the most posterior portion of the vermis whereas the pyramid is the most inferior The pyramid is separated superiorly (or posteriorly) from the tuber by the suprapyramidal fissure (or tubero-pyramidal fissure) and inferiorly from the uvula by the infrapyramidal fissure (or uvulo pyramidal fissure) — The nomenclature of the *fissures of the inferior vermis is confusing because of reversal of these* segments during embryologic development (Figs 3 and 4) The fissure behind the pyramid is prepyramidal in location early in embryologic development and postpyramidal in the fully developed cerebellum To avoid confusion, the term suprapyramidal (ref 4) is used for this fissure in this report Similarly, the fissure in front of the pyramid corresponding *to the vermian portion of the secondary* fissure is designated as *the* infrapyramidal fissure — Laterally, the pyramid is connected with

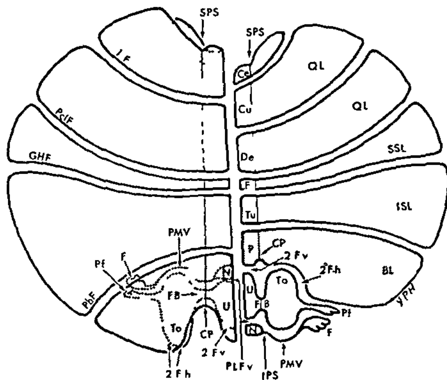


Fig 4 Diagrammatic view from above and behind of early (right) and later (left) stages Label d structures include the bi entral lobule (BL) central lobule (Ce) copula pyramidis CP) culmen (Cu) declive (De) flocculus (F) furrowed band (FB) folium (Fo) great ho izontal fissure (GHF) inferior paravermian sulcus (IPS) inferior semilunar lobule (ISL) nodulus (N) pyram d (P) prebiventral fissure (PbF) post-clival fissure (PclF) paraflocculus Pf) verm an port on of the postero-lateral fissure (PLF v) posterior medullary velum (PMV) quadra gular lobule (QL) superior paravermian sulcus (SPS) superior semilunar lobule (SSL) tons l (To) tuber (Tu) uvula (U) primary fissure (1 F) hemispheric portion (F h) and vermian portion (? F v) of the secondary fissure The paravermian sulci are i d cated by vertical lines

Th plane ew (right) emphas zes corresponding po tions of the vermis and hemisphere befor rotation The pyram do-copulo-biventral complex is shaded

The iew after rotation (left) shows that the flocculo-nodular lobe (N PMV and F) is now located bove the u ulo-tons llo-paraflocccular complex (U To and Pf) The portions covered by the shaded pyramid and biventral lobule as a result of rotation are indicated by dotted lines

the cerebellar hemisphere (biventral lobule) by a narrow but prominent ridge called the copula pyramidis (ref 1) (Figs 1 2 3 4 5) In contrast the uvula in front of the pyramid has a less conspicuous connection to the tonsil the fur rowed band of Reil (Figs 4 5 6) Because of rotation of the inferior part of the

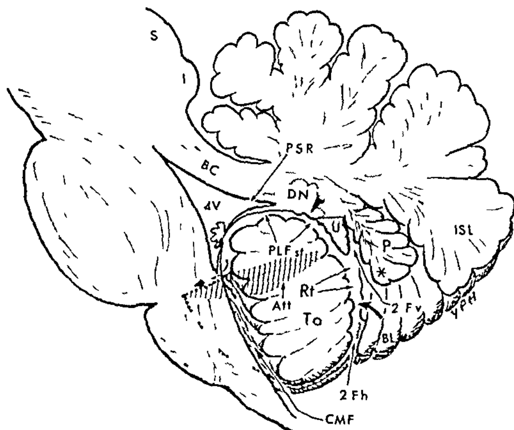


Fig 5 Parasagittal section of the cerebellum and brain stem showing the retrotonsillar space the tonsillo biventral notch and related cerebellar fissures

Labeled are the attachment (Att vertically shaded) of the cerebellar tonsil brachium conjunctivum (BC) biventral lobule (BL) cerebello medullary fissure (CMF) dentate nucleus (DN) inferior colliculus (I) inferior semilunar lobule (ISL) pyramid (P) supratonsillar portion of the postero lateral fissure (PLF st) posterior superior recess (PSR) of the 4th ventricle retrotonsillar space (Rt) superior colliculus (S) cerebellar tonsil (To) uvula (U) hemispheric and vermian portions of the secondary fissure (2 F h 2 F v) and 4th ventricle (4V) The furrowed band (large arrowhead) and the copula pyramidis (*) are also indicated The wing of the cerebellar tonsil covered by the brain stem is shown by dotted lines The uvula (U obliquely shaded) has been cut more deeply than the pyramid to demonstrate the lateral extension of the vermian portion of the secondary fissure (2 F v) and the supratonsillar portion of the postero lateral fissure (PLF st) The supratonsillar space (PLF st) is separated from the posterior superior recess (PSR) of the 4th ventricle by the posterior medullary velum and is continuous antero laterally with the peduncular portion of the postero lateral fissure (curved arrow with broken stem) above the wing of the cerebellar tonsil The retrotonsillar space (Rt) communicates with the postero lateral fissure (PLF st) the vermian (? F v) and the hemispheric portions (2 F h) of the secondary fissure and the vallecula medial to the tonsil The thick curved arrow indicates the tonsillo biventral notch

vermis during development (Fig 3), the surface of the copula pyramidis becomes the lowest portion of the inferior paravermian sulcus As described previously (8), the space around the superior pole of the cerebellar tonsil may be considered to

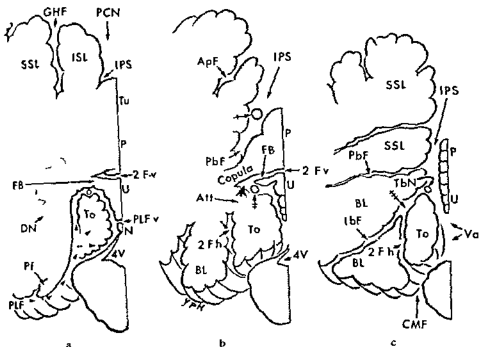


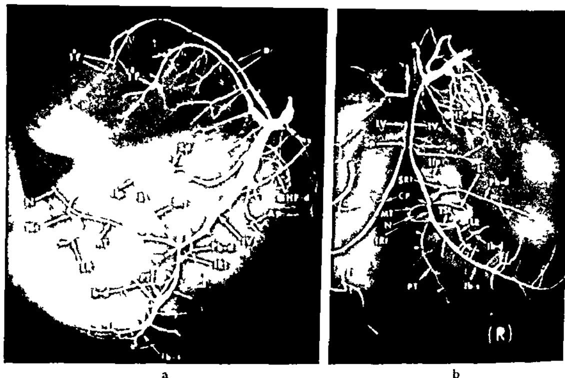
Fig 6 Serial horizontal se tion of the right half of the cerebellum and brain stem from above downward

Label d structures include the anso-paramed an f ssure (ApF) attachment (Att) of the ton il biventral lobule (BL) cerebello-medullary fissure (CMF) dentate nucleus (DN) fur rowed b nd (FB) great horizontal f ssure (GHF) intrabi entral fissure (IbF) inferior par a ermin sulcus (IPS) inferior semilunar lobule (ISL) nodulus (N) pyramid (P) prebiventral fis ure (PbF) posterior cerebellar notch (PCN) paraflocculus (Pf) postero-lateral fissure (PLF) verm an port on of the postero-lateral fissure (PLF v) superior semilunar lobule (SSL) ton illo-biventral notch (TbN) cerebellar tonsil (To) tuber (Tu) uvula (U) vallecula (Va) 4th entricle (4V) hemisp heric a d vermian portions of the secondary fissure (2 F h 2 F v)

a) S ction through the superior pole of the cerebellar tonsil (To) The space around the s iper or pole of the tonsil commu icates anteriorly with the peduncular and floccular portions of the postero-lateral fis ure (PLF) Med ally it is continuous with the vermian (or nodulo-uvular) port on of the postero-lateral fissure (PLF v) The vermian portion of th secondary f sure (F v) s separated f om the supraton illar space by the furrowed band (FB) Cro s sect on of a small essel seen anterior to the furrowed band is a supratonsillar tributary of the perior r trotonsillar vein

b) S ction thro gh the tonsillar attachment (Att) The retrotonsillar space (large arrow h ad o ttinue nt r orly nd medially with the inferior para ermian sulcus between uvula d to il nd poster orly with the vermian portion of the secondary fissure (2 F v) It is sep r ted from th poster or portion of the inferior paravermian sulcus (IPS) by the copula [illegible] Cros sect ons of the inferior vermian vein (←→) and its superior retrotons llar trib t ry ←→ are also nd c ted

S t o below the tons llar attachment. The hemispheric portion of the secondary fissure F h) joined by the intrab entral fissure (IbF) to form a common fissure (↔↔) which turn opens into the ton illo-b entral notch (TbN) A cross-section of an inferior retro-ton il r trib tary is also shown at this site Note the relat onship of the cerebello-medullary f ure CMF) nd th vallecula (Va) (Erratum SSL should be ISL.)



a b

c

Fig 7 Roentgenograms of an injected specimen in lateral (a) half axial (b) and basal (c) projections The contrast medium was injected into the torcular following ligation of both lateral and straight sinuses near the torcular The description given below is based on subsequent dissection For the lateral view the cerebellum and brain stem *were cut in half and only its right half (R) was* radiographed

Labeled structures include a vein running in the ansoparamedian fissure (Ap) furrowed band (*FB*) copular point (*CP*) declival vein (*Dc*) vein running in the depths of the great horizontal fissure (GHF d) veins running in the deep and superficial portions of the intrabiventral fissure (Ib d Ib s) vein running in the infrapyramidal fissure (Ifp) inferior retrotonsillar tributary (IRt) inferior vermian vein (IV) vein of the lateral recess of the 4th ventricle (LR) medial tonsillar vein (MT) vein running on the surface of the nodulus (N) vein in the depth of the prebiventral fissure (Pb d) posterior tonsillar tributary (PT arrowheads) suprapyramidal vein (Sp) superior retrotonsillar tributary (SRt) transverse supratonsillar vein (TSt) and vein running in the primary fissure (1 F)

In (a) the lateral tonsillar vein (unlabeled) is obscured by the medial tonsillar vein (MT) *In* (*c*) the superior and inferior retrotonsillar tributaries (SRt IRt) are superimposed and cannot be individually identified The unlabeled arrow in each figure indicates the same point in the course of the large intrabiventral tributary (Ib s) The superior retrotonsillar vein (SRt) is small in this case It outlines the posterior aspect of the upper part of the tonsil and runs postero *inferiorly* (*a*) and medially (b) its infrapyramidal tributary (Ifp) runs laterally (b) and then downward (a) behind the furrowed band (FB) (Legend contin on p 335)

be the supratonsillar portion of the postero-lateral fissure If the uvula and adjacent portion of the pyramid are removed a space between the copula posteriorly and tonsil anteriorly is exposed the retrotonsillar space The furrowed band flattens out and becomes rudimentary in the roof of this space As a result the postero-lateral fissure (anterior to the furrowed band) and the secondary fissure (posterior to the furrowed band) fuse in the retrotonsillar space Below the level of the copula pyramidis the retrotonsillar space opens inferiorly behind the cerebellar tonsil lateral to the paravermian sulcus on the medial surface of the hemisphere At this site there is a shallow depression or notch (the tonsillo-biventral notch) corresponding to a confluence of fissures secondary fissure inferior paravermian sulcus intrabiventral fissure and vallecula (Figs 1, 5 6) Similar confluence of fissures is also noted at the upper end of the posterior cerebellar notch These include the post clival fissures great horizontal fissures and inferior paravermian sulci

Angiographic appearances of the inferior vermian vein and its tributaries

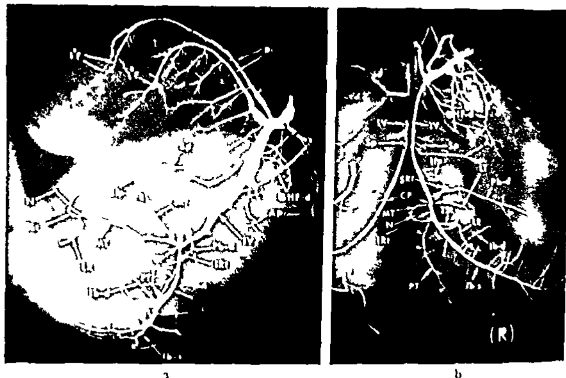
In typical form the inferior vermian vein originates behind the mid portion of the cerebellar tonsil immediately below the copula pyramidis It is formed by the union of superior and inferior retrotonsillar tributaries The former runs downward in the retrotonsillar space while the latter runs upward in the tonsillo-biventral notch (cf Figs 1 2 7) The common stem, the inferior vermian vein then runs upward and backward in the inferior paravermian sulcus At the upper end of the posterior cerebellar notch it joins the straight or lateral sinus either directly or indirectly after a short course in the tentorium

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Fig 7 (Continuation of legend p 334)

The inferior retrotonsillar vein (IRt) originates in the superficial portion of the intrabiventral fissure (Ib-s) runs posteromedially (c) and superiorly (a) (b) receiving a small tributary from the depth of the fissure (Ib-d) it is joined by a vein running along the superficial portion of the secondary fissure (posterior tonsillar tributary PT and row of arrowheads) to form a single trunk (IRt) in the tonsillo-biventral notch. The medial tonsillar vein (MT) communicates with the partially filled vein of the lateral recess (LR) via the transverse supratonsillar vein (TSt) A vein which runs on the superior surface of the nodulus can also be identified The lateral tonsillar tributary (LT) runs in the depth of the secondary fissure and is clearly seen only in (b) and (c)

Veins which drain into the inferior vermian vein also include a vein in the depth of the prebiventral fissure (Pb-d) and a vein running within the great horizontal fissure (GHF-d) The suprapyramidal vein (Sp) is seen in (a) but most of it is obscured in the other views unlabeled in ( ) The declival veins (Dc) are prominent one running in the midline the other adjacent to the d clival sulcus on the right side The latter originates in the lateral portion of the primary fissure (1 F) (b) (c) it is located more anteriorly as seen in the lateral view (a) because of the oblique course of the primary fissure



a b

c

Fig. 7. Roentgenograms of an injected specimen in lateral (a), half axial (b) and basal (c) projections. The contrast medium was injected into the torcular following ligation of both lateral and *straight sinuses near the torcular. The description* given below is based on subsequent dissection. For the lateral view, the cerebellum and brain stem were cut in half and only its right half (R) was radiographed.

Labeled structures include a vein running in the anso-paramedian fissure (Ap), furrowed band (FB), copular point (CP), declival vein (Dc), vein running in the depths of the great horizontal fissure (GHF-d), veins running in the deep and superficial portions of the intrabiventral fissure (Ib-d, Ib-s), vein running in the infrapyramidal fissure (Ifp), inferior retrotonsillar tributary (IRt), inferior vermian vein (IV), vein of the lateral recess of the 4th ventricle (LR), medial tonsillar vein (MT), vein running on the surface of the nodulus (N), vein in the depth of the prebiventral fissure (Pb-d), posterior tonsillar tributary (PT, arrowheads), suprapyramidal vein (Sp), superior retrotonsillar tributary (SRt), transverse supratonsillar vein (TSt) and vein running in the primary fissure (1 F).

In (a) *the lateral tonsillar vein (unlabeled) is obscured by the medial tonsillar* vein (MT). In (c) the superior and inferior retrotonsillar tributaries (SRt, IRt) are superimposed and cannot be individually identified. The unlabeled arrow in each figure indicates the same point in the course of the large intrabiventral tributary (Ib-s). The superior retrotonsillar vein (SRt) is small in this case. *It outlines the posterior aspect of the upper part* of the tonsil and runs postero-inferiorly (a) and medially (b); its infrapyramidal tributary (Ifp) runs laterally (b) and then downward (a) behind the furrowed band (FB). (Legend contin. on p. 335.)

The superior retrotonsillar tributary originates immediately behind the superior pole of the cerebellar tonsil It is formed by union of the several supratonsillar tributaries which run backward in the supratonsillar portion of the postero-lateral fissure Another tiny vein often runs downward behind the furrowed band (infrapyramidal vein) to enter the superior retrotonsillar vein The superior retrotonsillar vein runs downward backward and medialward in the retroton sillar space along the posterior surface of the upper half of the cerebellar tonsil It then runs around the copula pyramidis and joins the inferior vermian vein

The inferior retrotonsillar vein originates on the inferior surface of the biventral lobule It runs first posteromedially and then upward in the tonsillo-biventral notch to join the superior retrotonsillar vein in the region of the copula pyr amidis The exact course of the first part of this vessel depends upon its location in relation to the margins of the biventral lobule Several tributaries join the inferior retrotonsillar vein in the tonsillo-biventral notch at variable points These tributaries include veins running on the medial lateral and posterior aspects of the cerebellar tonsil below the tonsillar attachment Occasionally a midline vein which runs on the under surface of the uvula may join the inferior retrotonsillar

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Fig 8 (Continuation of legend p 336)

a) The superior retrotonsillar vein (SRt) continues into the inferior vermian vein (IV) with a characteristic sweep around the anterior inferior margin of the copula pyramidis (*) A fine vein (Ifp) in the infrapyram dal fissure between the uvula and the pyramid runs down ward to join the superior retrotonsillar vein The inferior retrotonsillar vein (IRt) in the tonsillo-biventral notch joins the superior retrotonsillar tributary immediately below the copula The suprapyramidal fissure between the tuber and pyramid is also indicated by a small vein (Sp) Several fine tributaries on the inferior surface of the cerebellar hemisphere run medially and then turn upward (arrowheads) in the posterior cerebellar notch to join the inferior ver mi n vein The precentral cerebellar vein (Pc) is also labeled

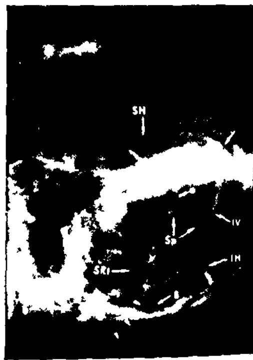
b) The infer or retrotonsillar tributary (row of arrowheads) which loops around the in ferior pole of the cerebellar tonsil is joined by a biventral vein (B) and the superior retro-tons llar tributary (SRt) to form the inferior vermian vein (IV) Tributaries of the inferior vermian vein include an inferior hemispheric vein (IH) and the suprapyramidal vein (Sp) A superior hem spheric vein (SH) in this case originates on the lateral portion of the inferior surface (o→) and then runs over the superior surface of the cerebellum to join (→→) the inferior vermian vein at the upper end of the posterior cerebellar notch Low position of the inferior retrotonsillar tributary may be due to Arnold Chiari malformation of first degree (not proven by encephalography)

c) Absent inferior retrotonsillar tributary Two inferior vermian veins (IV) one on each s d are seen these run at slightly d fferent depths in the posterior cerebellar notch The superior retrotons llar tributary (SRt) is prominent the dense dot at its origin represents a transverse supratonsillar tributary (TSt) There is also a vein (U) *running on the surface of the uvula* near the m dline A biventral vein (B) joins the inferior vermian vein behind the copula pyramid s ( ) The post-clival vein (Pcl) runs medially in the post-cl al fissure and joins the inferior vermian vein at the upper end of the posterior cerebellar notch

d) Abse it superior retrotonsillar tributary The inferior vermian vein (IV) is formed behind the copula pyram dis ( ) by union of the inferior retrotonsillar tributary (IRt) and a biventral vein (B) Ve ns running on the lateral aspect of the inferior surface of the hemisph re (IH) and in the great horizontal fissure (GHF) are also seen



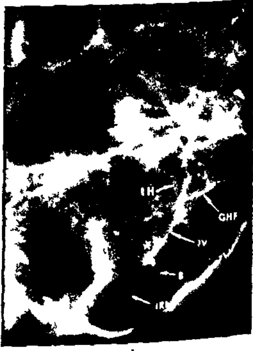
a



b



c



d

Fig 8 Normal inferior vermian vein and its tributaries in lateral projections (four cases) For continuation of legend see opposite page

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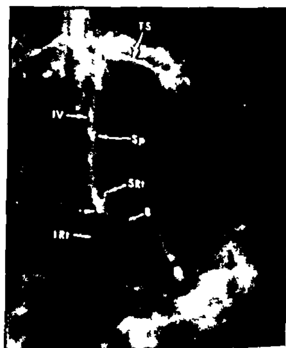
b) The inferior retrotonsillar tributary (row of arrowheads) which loops around the inferior pole of the cerebellar tonsil is joined by a biventral vein (B) and the superior retrotonsillar tributary (SRt) to form the inferior vermian vein (IV) Tributaries of the inferior vermian vein include an inferior hemispheric vein (IH) and the suprapyramidal vein (Sp) A superior hemispheric vein (SH) in this case originates on the lateral portion of the inferior surface (o→) and then runs over the superior surface of the cerebellum to join (→→) the inferior vermian vein at the upper end of the posterior cerebellar notch Low position of the inferior retrotonsillar tributary may be due to Arnold Chiari malformation of first degree (not proven by encephalography)

c) Absent inferior retrotonsillar tributary Two inferior vermian veins (IV) one on each side are seen these run at slightly different depths in the posterior cerebellar notch The superior retrotonsillar tributary (SRt) is prominent the dense dot at its origin represents a transverse supratonsillar tributary (TSt) There is also a vein (U) running on the surface of the uvula near the midline A biventral vein (B) joins the inferior vermian vein behind the copula pyramidis (*) The post-clival vein (Pcl) runs medially in the post-clival fissure and joins the inferior vermian vein at the upper end of the posterior cerebellar notch

d) Absent superior retrotonsillar tributary The inferior vermian vein (IV) is formed behind the copula pyramidis (*) by union of the inferior retrotonsillar tributary (IRt) and a biventral vein (B) Veins running on the lateral aspect of the inferior surface of the hemisphere (IH) and in the great horizontal fissure (GHF) are also seen



a



b



c



d

Fig. 9. Normal inferior vermian vein and its tributaries in semi-axial projection (four cases). For continuation of legend, see opposite page.



Fig 10 Anomalous tortuous inferior vermian vein a) A p projection The inferior retrotonsillar tributary (IRt) and the copular point (CP) are well filled on the *right side* The superior retrotonsillar tributary is not clearly identified A remarkably tortuous inferior vermian vein (1 2 and 3) runs posteriorly and superiorly in the posterior cerebellar notch and crosses to the opposite side b) Lateral view The inferior and superior retrotonsillar tributaries (IRt SRt) join to form the markedly tortuous inferior vermian vein (1 2 3)

Fig 9 (Continuation of legend p 338)

a) The superior (SRt) and the inferior retrotonsillar tributaries (IRt) unite to form the inferior vermian vein (IV) A typical hook or angle is formed between the superior retrotonsillar tributary and the inferior vermian vein at *the lower margin* of the copula pyramidis (small curved arrow) A similar configuration is also formed on the opposite side (arrowhead) although the posterior portion of the inferior vermian vein on this side is not opacified The inferior vermian vein on the right runs upward and turns abruptly laterally (>—>) at the upper end of the posterior cerebellar notch to join a tentorial *sinus* (→)

b) The inferior vermian vein (IV) is formed by the union of the superior retrotonsillar tributary (SRt) inferior retrotonsillar tributary (IRt) and biventral vein (B) at the copular point (unlabeled arrowhead) The inferior vermian vein runs upward and backward to enter a tentorial sinus (TS) The suprapyramidal vein (Sp) is *seen on end* The inferior retrotonsillar vein is tortuous in this case

c) On the right side (readers left) a typical superior retrotonsillar tributary (SRt) runs downward and backward to enter the inferior vermian vein *(IV) On the left side however* ro retrotonsillar tributaries are noted A vein arising on the medial or falcial aspect (→) of the cerebellar hemisphere runs forward and medially *to join the inferior vermian vein (IV) this vein forms* a wide loop which should be distinguished from the hook like junction of a superior retrotonsillar tributary with the inferior vermian vein Several suprapyramidal veins (unlabeled arrows) are seen on both sides

d) Multiple *tributaries of the inferior* vermian vein (IV) from the inferior surface of the hemisphere (IH) the superior retrotonsillar fissure (SRt) and the medial aspect of the cerebellar tonsil (row of unlabeled arrows) are seen

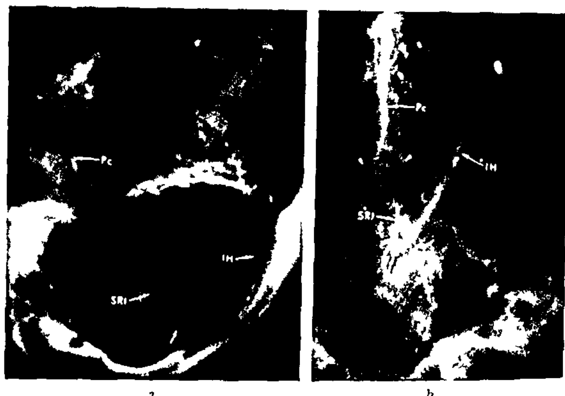


Fig. 11. Drainage of the retrotonsillar tributaries into an inferior hemispheric vein. a) Lateral view. The superior retrotonsillar tributary (SRt) after emerging from the retrotonsillar space runs downward and backward onto the inferior surface of the cerebellar hemisphere. It continues as an inferior hemispheric vein (IH) which joins the lateral sinus. The precentral cerebellar vein (Pc) is also faintly visualized. b) Half axial view. Drainage of the superior retrotonsillar tributary (SRt) into an inferior hemispheric vein (IH) is clearly evident. The precentral cerebellar vein (Pc) and its brachial tributaries (arrowheads) are also clearly seen.

vein. *Some of these tributaries may, however, open directly into the* superior retrotonsillar vein or inferior vermian vein rather than the inferior retrotonsillar vein. One rather constant tributary of the inferior vermian vein is a vein running in the suprapyramidal fissure between the pyramid and the tuber (suprapyramidal vein). Another frequent vessel is a vein which originates in the depth of the primary fissure on the superior surface of the cerebellum (cf. Fig. 1) and runs upward and backward. Upon emerging from the fissure, it turns backward and downward in or adjacent to the declival sulcus (a shallow groove between the declive and the quadrangular lobule) to join the inferior vermian vein near its dural end. This may be designated as the *declival vein* (Fig. 7).

The inferior vermian vein, formed by the union of the superior and inferior *retrotonsillar tributaries immediately below the copula pyramidis*, runs superiorly and posteriorly taking an arcuate course convex medially and postero-inferiorly



Fig 12 Occipital sinus The occipital sinus (OS) often single in its upper part runs in the midline and takes a straighter course than the inferior vermian vein (IV) A vein running along the secondary fissure (2 F) the superior retrotonsillar vein (between two arrowheads) an inferior hemispheric vein (IH) and a tentorial sinus (TS) are also indicated

(Figs 8 9) Although it may join the straight sinus 10 to 15 mm anterior to the torcular it often turns laterally at the upper end of the posterior cerebellar notch to join the lateral sinus (Fig 9) In the lateral view the superior retrotonsillar vein joins the inferior vermian vein with a characteristic antero-inferiorly convex curve corresponding to the anterior and inferior margin of the copula pyramidis (Figs 1 2 7 8 10) In the half axial projection an acute angle is produced at this junction with its inferiorly directed apex corresponding to the copula (Figs 1 2, 7 9) On films with fine detail, the supratonsillar supra and infrapyramidal tributaries may also be identified (Fig 8) In the half axial view, the inferior retrotonsillar vein runs medially and superiorly It joins the inferior vermian vein in continuous fashion or at a slight angle depending on its exact site of origin In the lateral view the course of this vein corresponds closely to the posterior margin of the lower pole of the cerebellar tonsil (Fig 7a)

In some cases the inferior retrotonsillar vein may be absent (Fig 8c) whereas in others the superior retrotonsillar vein may be rudimentary (Fig 8b) The inferior vermian vein may be extremely tortuous (Fig 10) It may not run in the inferior paravermian sulcus but in the posterior cerebellar notch at some distance behind the inferior vermis It may leave the notch entirely and run upward on the inferior surface of the cerebellar hemisphere before joining the

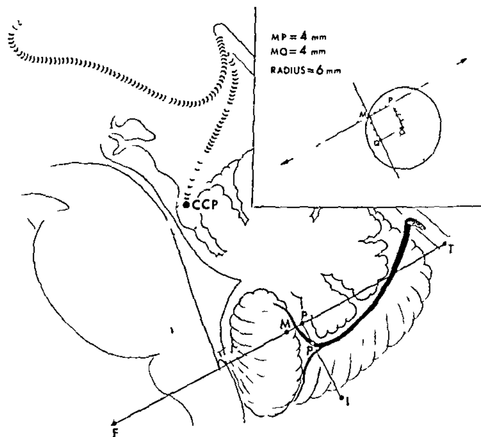


Fig 13 Normal measurements of the copular point A variety of measurements from the copular point (P) to other anatomical landmarks are indicated F anterior margin of the foramen magnum T torcular M midpoint of FT P the foot of a perpendicular dropped from P to FT I point of intersection between P P and inner table of the occipital bone CCP colliculocentral point of the precentral cerebellar vein

The insert shows the distribution of copular points in 50 presumably normal adult cases M midpoint of a line connecting the anterior margin of the foramen magnum and the torcular (FT) The center of distribution of copular points (O) was located 4 mm behind M and 4 mm below FT All copular points were within a circle of 6 mm radius with center at O

lateral sinus (Fig 11) A vein which should not be confused with the inferior vermian vein is the occipital sinus which is located in the midline and has the appearance of a dural sinus (Fig 12) adjacent to the bone

For purposes of measurement the most anterior point of the curve formed by *the superior retrotonsillar tributary and the inferior vermian vein* may be designated as the copular point (Fig 13) This point may not coincide exactly with the point of junction of the superior and inferior retrotonsillar tributaries The distance between this copular point and the anterior margin of the foramen magnum ranges from 3 7 to 5 1 cm with a mean of 4 4 cm as measured in 50 presumably *normal adult angiograms (target film distance* of 40 inches or

Table

Measurements of the copular point (for measurement points see Fig 13)

	Lower Limit	Upper Limit	Mean
FP	3 7 cm	5 1 cm	4 4 cm
PT	2 9 cm	4 0 cm	3 7 cm
PI	0 5 cm	1 8 cm	1 3 cm
PP	—0 1 cm	+1 0 cm	+3 6 cm
MP'	—0 1 cm	+0 9 cm	+3 6 cm
MT	7 6 cm	9 1 cm	8 0 cm
$\frac{FP'}{FT}$	0 5	0 59	
$\frac{PT}{FT}$	0 39	0 50	

102 cm) In these 50 cases the copular points were plotted in relation to the midpoint of a line connecting the anterior margin of the foramen magnum and the torcular In 98 per cent of cases these points fell within a circle of 6 mm radius with its center located 4 mm behind and below the midpoint (Fig 13 and Table) In only one case was the copular point located anterior to the midpoint of the line connecting the anterior margin of the foramen magnum and the torcular and in only two other cases was it located above this line

Acknowledgement

This work was supported in part by a research grant from the National Heart Institute National Institute of Health U S Public Health Service 1 R01 HE 09912 03 We would like to express our gratitude to Dr Paul Anderson of the Department of Neuropathology for his assistance and encouragement

SUMMARY

The anatomical course and roentgen appearances of the inferior vermian vein and its tributaries including the superior and inferior retrotonsillar supra and infrapyramidal and distal tributaries are described in detail For purposes of measurements the anterior inferior point of the angle formed by the inferior vermian vein and its superior retrotonsillar tributary may be designated as the copular point The location of this point and the configuration of this angle are significant angiographically in the diagnosis of posterior fossa space occupying lesions

ZUSAMMENFASSUNG

Der anatomische Verlauf und das röntgenologische Aussehen der Vena vermis inferior und deren Zuflüsse: die superioren und inferioren retrotonsillaren, die supra- und infrapyramidalen und die auslaufenden Zuflüsse werden im einzelnen beschrieben. Der anteriore inferiore Punkt, den die Vena vermis inferior und dessen superiorer retrotonsillarer Zufluss bilden, kann bei Messungen als »Kopulations-Punkt« bezeichnet werden. Bei der Diagnose raumfordernder Prozesse der Fossa posterior sind die Lokalisation des Punktes und die Konfiguration des Winkels angiographisch entscheidend.

RÉSUMÉ

Les auteurs décrivent en détail le trajet anatomique et l'aspect radiographique de la veine vermienne inférieure et de ses affluents y compris les veines rétro-amygdaliennes supérieures et inférieures, les veines supra- et infra-pyramidales et les veines déclivales. Pour effectuer les mesures on peut appeler «point copulaire» le point antérieur et inférieur de l'angle formé par la veine vermienne inférieure et son affluent rétro-amygdalien supérieur. La situation de ce point et la configuration de cet angle ont un intérêt en angiographie pour le diagnostic des tumeurs de la fosse postérieure.

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DEPARTMENTS OF NEURORADIOLOGY AND NEUROSURGERY, MANCHESTER ROYAL INFIRMARY, ENGLAND

UNUSUAL ANOMALY OF ANTERIOR CEREBRAL ARTERY

by

IAN ISHERWOOD and JOHN DUTTON

It is our intention to present two cases of an anomaly in the origin and course of the anterior cerebral artery not previously recorded angiographically nor surgically

Case 1 Female aged 59 The patient was admitted to hospital following a subarachnoid haemorrhage No source of the haemorrhage could be determined angiographically The anterior cerebral artery on the left side took origin from the internal carotid artery at the level of the ophthalmic artery and passed medially to join the right anterior cerebral artery at the normal level of the anterior communicating artery (Figs 1 and 2)

Case 2 Female aged 37 The patient who for twelve years had been known to be hypertensive and to have a coarctation of the aorta, was admitted to hospital following a subarachnoid haemorrhage Cerebral angiography demonstrated the same anomalous origin and course of the anterior cerebral artery on both sides (Figs 3 and 4) A saccular aneurysm was present on the left side arising from the site at which a normal anterior cerebral artery would have taken origin and a second saccular aneurysm was present at the bifurcation of the right middle cerebral artery Both aneurysms were surgically clipped and the coarctation of the aorta subsequently excised During craniotomy it was observed that the anterior cerebral artery passed beneath and medial to the optic nerve which itself was kinked by the abnormal position of the artery Several perforating vessels were seen to arise from the middle cerebral artery proximal and distal to the aneurysm (Fig 5)

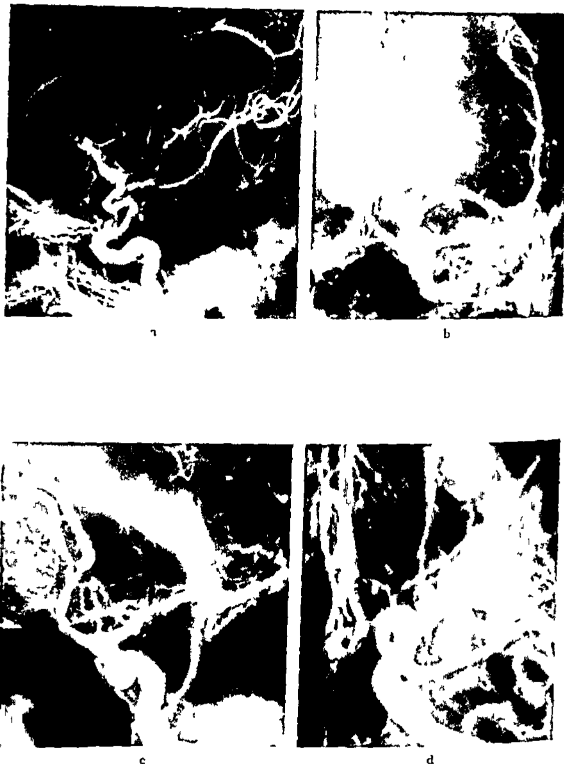


Fig 1 Case 1 Left common carotid angiography lateral (a) a p (b) transorbital oblique (c) and basal (d) projections demonstrating the anomalous origin and course of the anterior cerebral artery



Fig 2 Case 1 Right common carotid angiography a p projection with contralateral carotid compression The anomalous left anterior cerebral artery is demonstrated together with *normal right anterior* cerebral artery

Discussion

Only one report of a similar artery could be found in the literature (TURNBULL 1962) The artery was observed on the right side during a routine autopsy A complete agenesis of the opposite internal carotid artery was also present

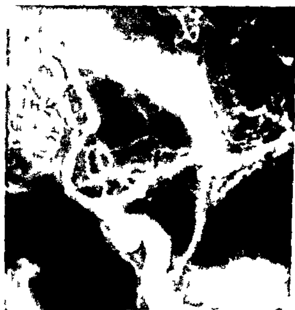
A similar angiographic appearance has been illustrated (DECKER 1956) and probably represents the same anomalous anterior cerebral artery beneath the optic nerve

Persistence of transitory branches and anastomoses found in the embryo account readily for most of the recorded variations and anomalies in the region of the internal carotid artery and the circle of Willis (PADGET 1948)

The complicated and late emergence of the definitive ophthalmic artery may offer an explanation for the presence of an anomalous artery beneath the optic nerve In the early embryonic stages (9 mm) the developing eye is supplied by branches of the primitive dorsal ophthalmic branch of the internal carotid artery Between the 7 to 12 mm stage a *second vessel* the primitive ventral ophthalmic artery derived from the cranial division of the internal carotid artery also contributes As the optic stalk elongates both primitive dorsal and ventral ophthalmic arteries are drawn out in length and about the 16 to 18 mm stage the stem of the primitive dorsal artery annexes the distal end of its companion ventral artery This secondary anastomosis takes place beneath the optic nerve so that for a time there is an arterial ring round the nerve As the expanding brain draws the


a


b


c


d

Fig 1 Case 1 Left common carotid angiography lateral (a) a p (b) transorbital oblique (c) and basal (d) projections demonstrating *the anomalous* origin and course of the anterior cerebral artery



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a



b



c



d

Fig 1 Case 1 Left common carotid angiography lateral (a) a p (b) transorbital oblique (c) and basal (d) projections demonstrating the anomalous origin and course of the anterior cerebral artery

a b

Fig 4 Case 2 Right common carotid angiography a p (a) and transorbital-oblique (b) projections Anomalous origin and course of the right anterior cerebral artery a saccular aneurysm at the bifurcation of the middle cerebral artery

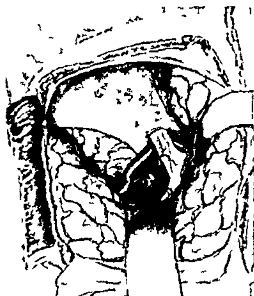
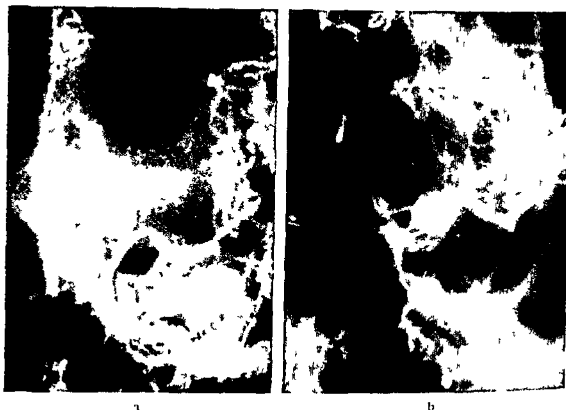


Fig 5 Schematic drawing of the surgical exposure of the left internal carotid aneurysm The anomalous anterior cerebral artery passes medially beneath the optic nerve kinking it.



a b

Fig 3 Case 2 Left common carotid angiography a p (a) and transorbital oblique (b) projections Anomalous origin and course of the left anterior cerebral artery a saccular aneurysm at the site of the normal origin of the anterior cerebral artery

cerebral arteries away from the optic region, the main ophthalmic stem, originally the dorsal ophthalmic artery, migrates caudally down the internal carotid by a series of 'anastomotic loops Additional anastomoses also occur with the primitive stapedial artery This complex development accounts for some of the better known anomalous arterial arrangements in this region It may offer an explanation for the persistence of a vessel which subsequently forms the anterior cerebral artery beneath the optic nerve

The arterial anastomosis in the chiasmal region may offer an alternative explanation

The pre chiasmal arterial anastomosis (Dawson 1958) occupies the angle between the optic nerves and takes the form of a series of loops of vessels along the medial aspects of the intracranial segments of the optic nerves and the anterior border of the optic chiasm It is supplied from three main sources (1) the pre chiasmal branch of the ophthalmic artery, (2) the superior hypophyseal branch of the internal carotid artery, and (3) the chiasmal branches of the anterior cerebral artery

RÉSUMÉ

Description de deux cas d anomalies rares de l artere cerébrale antérieure Cette art re qui etait unilaterale dans un cas et bilaterale dans l autre avait son origine sur l artere carotide interne au niveau de l artere ophtalmique et se dirigeait vers la ligne mediane en passant sous le nerf optique Ces deux malades ont eu une hemorragie sous arachnoidienne Dans le second cas il y avait des anevrysmes multiples et une coarctation de l aorte

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Thus is created an arterial circle within the circle of Willis around the optic nerve

Variation in size of these arteries constituting the arterial circle has been observed during dissection (DAWSON 1948) and it is possible that the portion of the circle beneath the optic nerve has in the two cases in question persisted as the main source of supply to the anterior cerebral artery

Conclusion

The significance of the angiographic observation which itself is characteristic, is two-fold firstly the importance of pre surgical recognition of the anomaly and secondly the possible effect, if later degenerative changes supervene, of an unusual compression of the optic nerve

The presence of an aneurysm at the site of what would have been the normal anterior cerebral artery in the second patient lends support to the theory that incomplete involution or atrophy of temporary arteries or of arteries normally *present in the adult form may be related to the formation of congenital* aneurysms

Acknowledgements

We should like to thank Dr R G W Ollerenshaw and the Department of Medical Illustration of the Manchester Royal Infirmary for the preparation of the prints and Mr R A H Neave for the drawing in Fig 5

SUMMARY

Two cases exhibiting an unusual anomaly of the anterior cerebral artery are described The artery which was unilateral in one case and bilateral in the other originated from the internal carotid artery at the level of the ophthalmic artery and passed medially beneath the optic nerve Both cases presented with a subarachnoid haemorrhage In the second case multiple aneurysms and a coarctation of the aorta were present

ZUSAMMENFASSUNG

Es wird uber zwei Falle einer ungewohnlichen Anomalie der A cerebralis *anterior berichtet* Die Arteria die in einem Falle unilateral und im anderen bilateral war entsprang der A carotis interna am Niveau der A ophthalmica und setzte medial unter dem Nervus

RÉSUMÉ

Description de deux cas d anomalies rares de l artere cerebrale anterieure Cette artère qui était unilatérale dans un cas et bilaterale dans l autre avait son origine sur l artère carotide interne au niveau de l artère ophtalmique et se dirigeait vers la ligne mediane en passant sous le nerf optique Ces deux malades ont eu une hemorragie sous arachnoidienne Dans le second cas il y avait des anévrysmes multiples et une coarctation de l aorte

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SERIAL ANGIOGRAPHIC EVALUATION OF CEREBROVASCULAR DISEASE

by

STEPHEN A KIEFFER, MILTON ALTER, JOSEPH A RESCH and KURT AMPLATZ

As part of a continuing comprehensive study of cerebrovascular disease, angiography has been performed on 128 patients with a clinical diagnosis of cerebrovascular occlusion at the University of Minnesota Hospitals Of this group, twenty patients have had follow-up angiographic studies one or more years later This paper summarizes the changes demonstrated in number as well as in severity of occlusive lesions

Material and Methods Admission to the cerebrovascular disease study was restricted to patients with a clinical history and physical findings compatible with a cerebral vascular occlusion whose acute episode began less than one month prior to admission to hospital and who were either clinically stable or improving at the time of examination Patients with known cerebral hemorrhage, fulminant clinical course, or increased cell count in the cerebrospinal fluid were excluded from the study (BALOW et coll 1966)

On the initial angiographic examination, an effort was made in each patient to obtain a complete evaluation of the extracranial and intracranial circulation

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without unnecessary arterial punctures This was obtained in most cases by selective catheterization of the four major vessels supplying the head and neck Specially molded catheters were introduced percutaneously into the axillary, subclavian or femoral arteries and positioned in or adjacent to the orifice of each major vessel (AMPLATZ et coll 1963) On this initial study the extracranial and intracranial distribution of each artery and its branches was demonstrated in two planes In general, the follow up study demonstrated all the brachiocephalic vessels but intracranial examination was limited in many patients to the side of clinical localization

Of the twenty patients studied, fourteen were males and six were females The mean age at the time of initial examination was 62 4 years The mean interval between angiographic studies was 2 years

For purpose of recording and statistical analysis a strictly anatomic angiographic system was developed (KIEFFER et coll 1967) The degree of narrowing of the arterial lumen was expressed as a percentage of the diameter just proximal to the area of narrowing as tabulated below

Grade	Occlusion of lumen diameter
0	0
1	1–24
2	25–49
3	50–74
4	75–90
5	90+

The length of the stenotic area was also noted although for the purpose of this study comparisons were based only on percentage reduction of the lumen diameter Since comparisons were based on ratios numerical differences between studies based on variations in technique were eliminated

Findings

Of the twenty patients followed in the manner outlined above, fourteen (70 %) showed significant (25 % or greater reduction in lumen diameter) extracranial or intracranial vascular occlusive disease on the side predicted by the clinical examination Of the remaining six patients whose initial angiographic examinations were negative two had narrowing in an appropriate vessel on the follow up study two had very mild or transient clinical signs without angiographic abnormality and one had brain stem signs perhaps due to involvement of a vessel too small to be seen on angiography The remaining patient had clinical signs maximal in the lower limb with no angiographic changes

Table

Improvement on serial angiography

Case	Vessel improved	Grade change	Other vessels	Grade change
1	Left middle cerebral	5 → 4	Right internal carotid	0 → 5
3	*Right middle cerebral*	5 → 0	Right internal carotid	2 → 3
7	Left internal carotid	5 → 3	Right internal carotid	5 → 5
19	Left internal carotid	5 → 3	Left middle cerebral	* → 5

* The proximal portion of the left middle cerebral artery was not visible on the original film due to complete occlusion of the left internal carotid in the neck

When the first and second angiographic examinations were compared, improvement was noted in four patients Aggravation of the angiographic picture, manifested by demonstration of either increased severity of a previously described occlusive lesion or of a new lesion, was observed in three cases Thirteen patients showed no significant change on follow up angiography Of the four patients showing improvement on the second angiography all had complete occlusions on the initial study, two involving the proximal internal carotid artery and two involving the proximal portion of the middle cerebral artery In at least two of these four patients, however, angiographic evidence of increased occlusive disease in other vessels was noted on the follow up examination (see Table)

Six patients deteriorated clinically in the interval between initial angiography and the follow up study In only two of these, however, was angiographic evidence of aggravation of the disease obtained at the follow up examination Three were unchanged and one actually had improved

Illustrative cases

Case 1 A 15 year old female was admitted initially in 1963 with a recent onset of right hemiparesis Angiography demonstrated complete occlusion of the right internal carotid artery at its origin (Fig 1) and nearly complete occlusion of the origin of the left internal carotid artery The flow through the left internal carotid artery past the area of extensive stenosis was delayed contrast filling of the left middle cerebral artery predominated There was collateral flow via branches of the external carotid artery to the ophthalmic artery and into the internal carotid artery Collateral flow was also evident via the posterior communicating artery and via leptomeningeal anastomoses between peripheral branches of the posterior cerebral and middle and anterior cerebral arteries (Fig 2a)

On re examination in 1965 (Fig 2b) the right internal carotid artery was still completely occluded However there had been considerable improvement in the stenosis of the left internal carotid artery Collateral flow was no longer evident nor was circulation time delayed In spite of this angiographic improvement there was no significant change in the patient s clinical status at the time of re evaluation



Fig 1 Case 1 Selective cath terization of brachiocephal c vessels via the subclavian artery in a 45 year old female with *recent onset of right hemiparesis* a) Complete occlusion of *right internal* carot d artery at its origin b) Severe stenosis of proximal portion of left internal carot d artery Distal to this stenosis the artery is small

Case 2 A 59 year old female *with right hemiparesis* had a nearly complete occlusion of the proximal l ft internal carotid artery a few *centimeters abov*e the carotid bifurcation (Fig 3) Examination ? years later revealed considerable improvement in the appearance of this lesion However there was no significant *change in* the patient s clinical picture In addition intracranial follow up study *revealed complete* occlusion of the ascending fronto-parietal branch of the left middle cerebral artery

The occlu ion which likely accounted for the patient s neurologic signs improved but a complete occlusion of a major intracranial *ves el on the same side* was noted on follow up an iography The patient s clinical status remained unchanged

Case 3 A 66-year-old male presented in 1965 with left hemiparesis and aphasia Angiography at that time was entirely normal (Fig 4) Re-examination in 1967 however showed complete occlu ion of the right middle cerebral artery Despite this change there had been no alteration in the clinical status of the patient

Thus in this case the initial angiogram was normal Two years later however a vessel which could have produced the initial syndrome was *occluded*

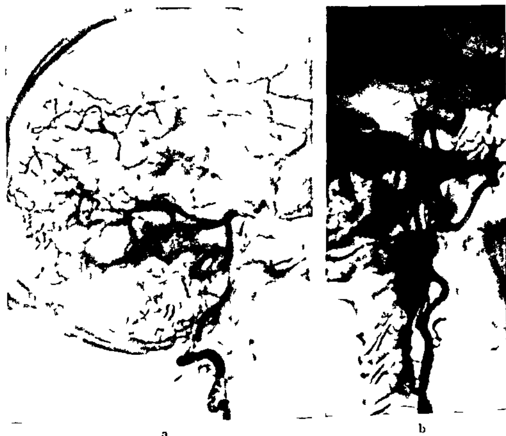


Fig. 2. Case 1. a) Selective injection of a large left vertebral artery. Collateral flow via posterior communicating artery into the internal carotid artery. Retrograde flow in branches of the middle cerebral artery which fill via leptomeningeal anastomoses from branches of the posterior cerebral artery. b) Follow-up transaxillary angiography 2 years later. Selective left common carotid injection demonstrating widening of the lumen of the proximal internal carotid artery; collateral flow was no longer evident on the left side.

Discussion

The literature contains several reports attempting to correlate clinical impairment with angiographic demonstration of stenotic lesions. In 1960, BULL, MARSHALL & SHAW found stenotic lesions in 41 % of a group of 80 patients with the stroke syndrome. However, they examined only one major vessel on the side of the clinical localization. More recent reports (BURROWS & MARSHALL 1965, CHASE & KRICHEFF 1966), utilizing angiography of the four major vessels supplying the head and neck, have shown a higher percentage correlation. Our initial studies in this group demonstrated 14 patients with significant extracranial or intracranial vascular occlusion on the side of clinical localization, a correlation of 70 %. Two additional patients with negative angiograms showed lesions constricting 50 % or more of the lumen diameter on follow-up examinations, thus

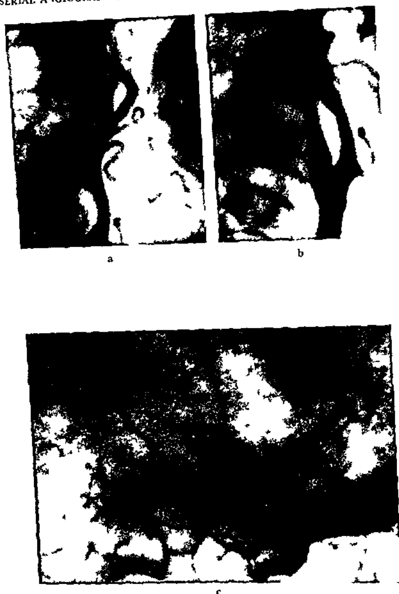


Fig 3 Case 2 Recent onset of right hemiparesis in a 59 year-old female a) Trans ubclavian angiography Almost complete occlusion of proximal left internal carotid artery b) Considerable widening of the stenotic area on follow up transaxillary left carotid angiography 2 years later c) Complete occlus on of ascending frontoparietal branch of left middle cerebral artery Later films d monstrated retrograde filling of occluded middle cerebral branches via leptomeningeal anastomoses with peripheral branches of the anterior cerebral artery

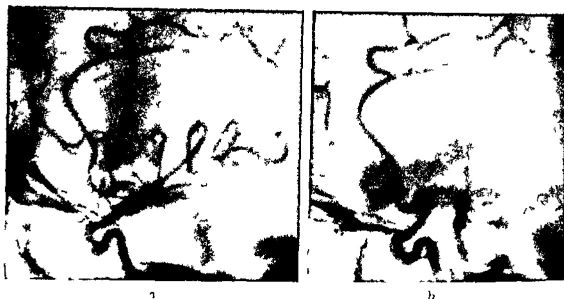


Fig. 4. Case 3. Recent onset of left hemiparesis and aphasia in a 66 year old male. a) Trans axillary catheterization of right common carotid artery. Normal angiography. b) Transfemoral catheterization of innominate artery 2 years later. Complete occlusion of proximal right middle cerebral artery; despite this angiographic change there was no change in the patient's clinical status.

giving a final overall angiographic correlation of 80 %. This relatively high per centage again emphasizes the importance of complete angiography in the evalua tion of the stroke patient.

Nevertheless, it must be emphasized that other factors not evident on angio graphy play a part in the production of the clinical picture of stroke. Of six patients who deteriorated clinically between the first and second angiographic examinations, the second study showed no appreciable angiographic change in three, aggravation in two, and improvement in one. Although for a given cere bral vascular accident, it is less effective in showing changes which correlate with the clinical course in stroke victims.

The mechanism by which four patients in this series showed improvement of a complete or nearly complete blockage of an artery is uncertain. Similar im provements in the distal internal carotid and proximal middle cerebral artery have been reported by several authors (Gannon & Chait 1962, Bladin 1964, Hollin & Silverstein 1965), the largest series being that of Bladin. To our knowledge, however, improvement of such lesions in the proximal portion of the internal carotid artery has not heretofore been reported. Whether the improve ment is due to fragmentation of thrombi with peripheral migration of these

fragments, relenting of spasm or dissolution of atherosclerotic or thrombotic material remains uncertain

In general these studies have demonstrated no uniform pattern of progression Angiographic improvement could not be related to the age and sex of the patients or to the use of anticoagulants Neither could medical disorders such as heart disease hypertension or diabetes be related to a tendency toward angiographically demonstrated aggravation of the condition

SUMMARY

Twenty patients with stroke syndrome were carefully evaluated clinically and angiographically (complete four vessel study) within one month of the onset of their acute episode and restudied a year or more later Analysis of the serial angiographic studies revealed no uniform pattern of progression of angiographically demonstrable atherosclerosis Four patients with complete occlusion of a major extracranial or intracranial artery showed significant angiographic improvement on the follow up study However selective four vessel angiography demonstrated worsening in other vessels in three of these four patients Although there was an 80 % correlation of the clinical findings with significant narrowing or occlusion on the side expected the changes recorded on the follow up examinations appeared to have no consistent relationship to the clinical course of the stroke victims

ZUSAMMENFASSUNG

Zwanzig Patienten mit Schlaganfallsyndrom wurden klinisch und angiographisch einer orgfaltigen Untersuchung (komplette Vier Gefass Studie) innerhalb eines Monats nach der akuten Attacke und Nachuntersuchungen ein oder mehrere Jahre spater unterworfen Analyse der angiographischen Serienaufnahmen zeigte kein gleichformiges Bild von angio-sorgfaltigen Untersuchung (komplette Vier Gefass-Studie) innerhalb eines Monats nach der graphisch demonstrierbarer fortschreitender Atherosklerose Vier Patienten mit vollstandigem Verschluss einer grosseren intra oder extrakraniellen Arterie zeigten eine deutliche Besserung bei einer spateren Untersuchung Vier Gefass Arteriogramme zeigten allerdings Verschlechterung des Befundes in anderen Arterien in drei der vier Patienten Obgleich eine 80 prozentige Korrelation der klinischen Befunde erreicht wurde mit signifikanter Verengung oder Okklusion auf der angegriffenen Seite konnten die bei Nachuntersuchungen beobachteten Rontgenbefunde nicht im Einklang mit dem klinischen Verlauf des Syndroms dieser Patienten gebracht werden

RÉSUMÉ

Vingt malades ayant présente un syndrome d ictus ont éte soigneusement examines cliniquement et angiographiquement (examen complet des quatre vaisseaux) dans le mois qui a suivi le debut de leur épisode aigu et étudies de nouveau un an ou plus apres L analyse des examens angiographiques en série n a pas montre un type uniforme de progression des

lesions athérosclércuses visibles par l angiographie *Une etude angiographique repetee a* montre une amélioration remarquable chez quatre malades qui avaient une occlusion complete des artères principales extracraniennes et intracraniennes Cependant une angio graphie selective carotide vertebrale bilaterale a montre une aggravation dans d autre arteres chez trois des quatre malades Bien qu on ait trouve une correlation de 80 % avec les signes cliniques, comportant une stenose importante ou une occlusion arterielle du cote prévu les lesions observees sur les examens ultérieurs n ont pas de façon constante une évolution parallele a l evolution clinique des malades atteints d ictus

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CHAIRE DE RADIOLOGIE (PROF J LEGRE) ET SERVICE DE NEUROCHIRURGIE (DR R P VIGOUROUX) DE LA FACULTE DE MEDECINE DE MARSEILLE FRANCE

L'ANGIOGRAPHIE DANS LES CONTUSIONS CEREBRALES

par

J LEGRE R P VIGOUROUX J LAVIEILLE G GIUDICELLI M DUFOUR A RAKOTOBE C BAURAND M CHOUX et C CHAIX

Notre travail est base sur l etude de 421 dossiers de traumatises craniens ayant eu une angiographie cerebrale Parmi ceux ci nous en avons elimines 171 qui presentaient des hematomes intra craniens Sur les 250 contusions cerebrales etudiees 24 seulement ont subi une intervention

Les criteres cliniques et paracliniques sur lesquels fut fonde le diagnostic de contusion cerebrale etaient les suivants tous nos malades avaient subi un traumatisme cranien important avec ou sans fracture ayant toujours entraine un trouble de la conscience et souvent un coma.

Le diagnostic anatomique de contusion cerebrale a ete base sur l existence de signes cliniques ou electriques ou les deux a la fois permettant d affirmer une focalisation hemispherique

Sur 250 contusions électrocliniques nous avons trouve 120 angiographies pathologiques et 130 angiographies dans les limites de la normale cette constatation ne permet nullement a notre avis d eliminer le diagnostic de contusion cerebrale mais prouve seulement que plus de la moitie des contusions ne presentent pas de modification vasculaire appreciable dans l etat actuel de nos moyens d investigation

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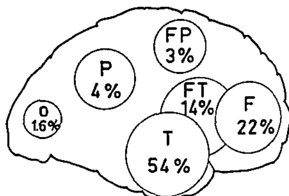


Fig 1 Localisations topographiques

Les criteres angiographiques pathologiques ont ete recherches aux temps arteriel, capillaire et veineux, ils sont essentiellement constitues par des deplacements des vaisseaux ou par des zones de vide vasculaire en rapport avec la localisation topographique de la contusion

Les *principales localisations topographiques* que nous avons rencontrees etaient les suivantes

Temporales	65
Frontales	27
Fronto temporales	17
Parietales	5
Fronto-parietales	4
Occipitales	2

Ce tableau fait apparaitre l existence de trois localisations principales temporale, frontale et fronto temporale, avec predominance nette de la localisation temporale puisqu elle comporte plus de la moitie des cas, 65 sur 120 (54 %) (voir Fig 1)

Les rapports anatomiques etroits des lobes frontal et temporal avec les saillies osseuses agressives de l etage moyen et de l etage anterieur de la base du crâne sont a l origine de ces localisations predominantes

Resultats statistiques des deplacements vasculaires dans les principales localisations

Contusions temporales (65 cas) (Figs 2 et 5) De profil l artere sylvienne est pratiquement toujours interessee par la contusion, puisque nous avons trouve ses segments M1, M2, et M3 souleves ou tendus dans 64 sur 65 cas (98 %) L etire

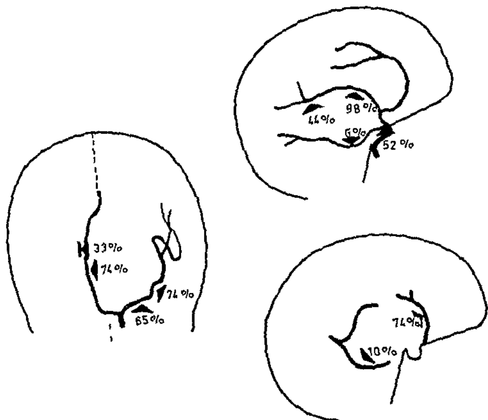


Fig 2 Schémas angiographiques des contusions temporales

ment du siphon carotidien est assez fréquent dans les localisations antéro-internes puisque nous l'avons observé dans plus de la moitié des cas 34 *sur* 65 (52 %) Au phlébogramme le soulèvement des veines sylviennes existait dans 48 sur 65 cas (74 %) *De face* les deux premier segments de l'artère sylvienne sont presque toujours refoulés M1 *dans* 43 cas (65 %) et l'angle M1—M2 dans 48 cas (74 %) sur 65 cas *Par contre* nous n'avons retrouvé que dans un très petit nombre de cas, l'*aspect en* ligne brisée décrit par l'école Lilloise L'artère péricalleuse est très *fréquemment* déviée mais l'importance du déplacement est toujours faible Au phlébogramme le déplacement de l'ampoule de Galien ne s'observe que dans un tiers des cas

Contusions frontales (27 cas) (Fig 3) Les secondes par ordre de fréquence elles se caractérisent comme suit De *profil* par un refoulement presque constant

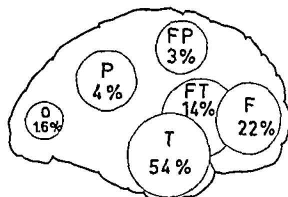


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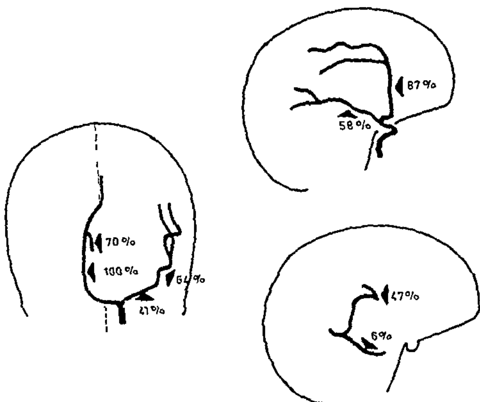


Fig 4 Schemas des contusions fronto-temporales

deplacements vasculaires plus accuses presentant certains caracteres associes des localisations frontales et temporales De profil le deplacement en arriere de l'artere cerebrale anterieure est moins accuse mais l'artere est plus tendue verticalement De face par contre le deplacement est tres accuse et constant 17 sur 17 cas (100 %) En ce qui concerne l'artere sylvienne, l'angle M1—M2 est aplati 11 sur 17 cas (64 %) en incidence de face Par contre de profil le soulevement de l'artere est moins accuse (58 %) Au phlebogramme l'ampoule de Galien est deplacee du cote oppose dans 70 % des cas

Les autres localisations parietales fronto parietales et occipitales sont en nombre trop restraint dans notre serie pour que l'on puisse en degager une semeiologie valable

En ce qui concerne plus particulierement les contusions de la region occipitale on soulignera la difficulte d'appreciation des modifications topographiques des

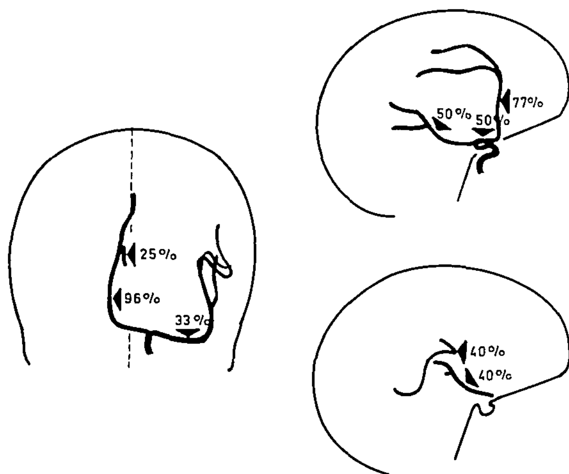


Fig. 3. Schémas angiographiques des contusions frontales.

du premier segment de l'artère cérébrale antérieure, 21 sur 27 cas (77 %), le refoulement est d'autant plus accusé que la contusion est plus antérieure et plus *importante. Le siphon carotidien est écrasé dans la moitié des cas (14 sur 27).* Au phlébogramme, nous avons observé, dans plusieurs cas, une avascularisation du pôle frontal. La veine de Galien était refoulée dans plus du tiers des cas. De face, la déviation de l'artère cérébrale, du côté opposé, est quasi constante, 26 sur 27 cas (96 %), mais l'importance de la déviation est moindre que dans les hématomes intracérébraux, elle est déplacée en totalité mais d'une façon moins accusée. Dans 33 % des cas (9 sur 27), le premier segment de l'artère sylvienne est abaissé.

Contusions fronto-temporales (17 cas) (Fig. 4). Cette troisième localisation, par ordre de fréquence, intéresse habituellement des contusions plus étendues entraînant un oedème cérébral important, se traduisant à l'angiographie par des

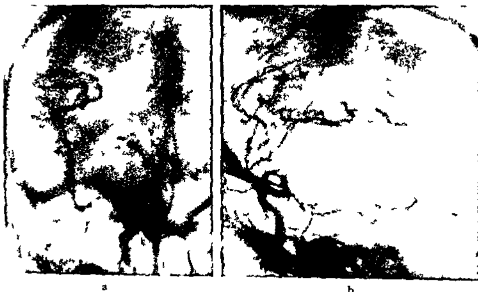


Fig 6 Hematome intra-cerebral non traumatique a) De face Refoulement en masse de l'artère sylvienne de l'artère cerebrale et de l'artère pericalleuse L'artère sylvienne a l'aspect beaucoup plus tendue et est verticalisee b) De profil Modifications vasculaires superposables à celles de la *contusion*

Si a de grande deplacements vasculaires s associent des plages de vide vasculaire, l intervention conduira a vider une partie de la totalite du lobe cerebral lyse

L association d un hematome intra ou extradural decele par un vide vasculaire peripherique, ne fera que confirmer la decision operatoire

C est ainsi que sur une serie de 42 malades operes pour *signes* angiographiques majeurs nous avons trouve 18 hematomes intracerebraux et 24 contusions

3^{em} cas Cette derniere eventualite qui pose le veritable *probleme* au neuroradiologue et au neurochirurgien est celle d une contusion avec *deplacements* vasculaires de moyenne importance pour laquelle le diagnostic *entre* contusion et hematome intracerebral se pose mais est difficile a resoudre aussi bien sur le plan clinique que radiologique (Fig 6)

Il semble que dans ces cas douteux *seule* l evolution clinique et la surveillance par angiographie iterative permette une decision soit d abstention chirurgicale soit d *intervention* dans laquelle peseront d ailleurs les convictions personnelles du neurochirurgien *puisque les* opinions des diverses ecoles sont souvent tres differentes sur la conduite a tenir

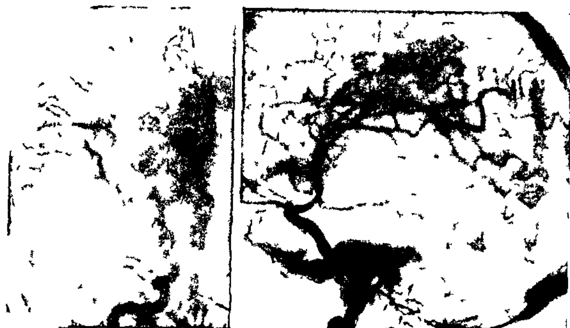


Fig 5 Contusion temporale avec aspect en ligne brisée de face et de profil Soulèvement sylvien et abaissement de la cérébrale postérieure circonscrivant un vide vasculaire

vaisseaux de cette région, car la vascularisation est beaucoup moins riche dans les zones distales que dans les régions temporale ou frontale

D autre part, les artères postérieures, n étant que rarement opacifiées par voie carotidienne, il serait nécessaire de pratiquer une angiographie vertébrale L état, habituellement grave, des traumatisés craniens contre indique une telle exploration

Conclusion

L intérêt neuro-chirurgical des modifications angiographiques observées au cours des contusions cérébrales repose d une part sur leur valeur diagnostique et localisatrice mais aussi, et surtout, sur l importance des déplacements vasculaires

Trois cas sont à considérer

1er cas Le déplacement vasculaire est minime ou nul, il est en faveur d une contusion simple, à l exclusion, a priori, d une collection sanguine, sa constatation conduira à l abstention chirurgicale

2me cas Le déplacement vasculaire est considérable, associé ou non à un vide vasculaire, il orientera plus volontiers vers une intervention neurochirurgicale, puisque, à la contusion indiscutable, s associe une lyse cérébrale ou un hématome intracérébral qui sera à rechercher avec soin

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RÉSUMÉ

Le travail a porte sur 421 traumatises crâniens ayant eu une angiographie cerebrale Après avoir éliminé 137 observations d'hématomes intracraniens 292 malades présentaient des signes cliniques et electriques de contusion Malgre le diagnostic probable de contusion mais du fait de l'importance des deplacements vasculaires 21 ont ete operes Sur 271 non opérés 122 cas avaient une angiographie normale Ce sont les cas restants qui nous ont permis d'essayer de preciser les criteres angiographiques des contusions cérébrales permettant d'eviter une intervention

SUMMARY

Cerebral angiography was performed in a material of 421 cases of cranial trauma After eliminating 137 cases which displayed signs of intracranial hematoma there were 292 cases with clinical and EEG signs of contusion Despite the angiographic diagnosis of probable contusion 21 cases were operated upon because of significant vasular displacements The angiographic findings were normal in 122 of the non operated cases An analysis was made of the remaining cases in an attempt to determine the angiographic criteria for a diagnosis of cerebral contusion and thus avoid surgical intervention

ZUSAMMENFASSUNG

Cerebrale Angiographie wurde in 421 Fällen von Schadeltrauma durchgefuhrt In 137 von diesen Fallen wurden intrakranielle Hamatome diagnostiziert und in 292 Fallen wurden klinische und elektrophysiologische Zeichen von Kontusion beobachtet Bei 21 von den letzteren Fallen wurde Operation auf Grund erheblicher Gefassverschiebung vorgenommen obwohl die Diagnose auf Kontusion hinwies Die angiographischen Befunde waren in 122 von den nicht operierten Fallen normal Eine Analyse der restierenden Fälle wurde vorgenommen um durch Feststellung der angiographischen Kriterien der cerebralen Kontusion operative Eingriffe vermeiden zu konnen

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FROM THE DEPARTMENTS OF RADIOLOGY AND SURGERY, TULANE UNIVERSITY SCHOOL OF MEDICINE AND CHARITY HOSPITAL OF LOUISIANA, NEW ORLEANS, U. S. A.

'MENINGIOMA BLUSH' IN PITUITARY ADENOMA

by

HAROLD Z. LEHRER and DONALD E. RICHARDSON

A meningioma-like accumulation of contrast medium may occur on carotid angiography of pituitary chromophobe adenomas. Although this phenomenon has been reported previously (ECKER & RIEMENSCHNEIDER 1955, KRICHEFF & SCHOTLAND 1964), it is fairly uncommon and perhaps not widely appreciated. The resemblance to meningioma may be heightened if extra-dural arteries, large enough to be clearly demonstrated on arteriograms, supply the tumor. In such cases, differentiating a pituitary adenoma from a meningioma may pose a difficult pre-operative diagnostic problem. The anatomical and pathophysiologic bases for the phenomenon will be discussed following the case presentations.

Case reports

Case 1. A 35-year-old woman was referred to the Charity Hospital in May 1966 because of visual difficulties over the preceding six to eight months. She had also noted some thinning of the hair over her scalp. Her menses had been irregular over the past year and absent for the past five months.

The general physical examinations disclosed only obesity and mild hypertension. She was neurologically intact, except for her visual fields which showed a large central scotoma on the right side and bilateral inferior temporal quadrantanopsia. On conventional films the anterior clinoids were sharpened, without upward displacement. The pituitary fossa was within normal limits of size.

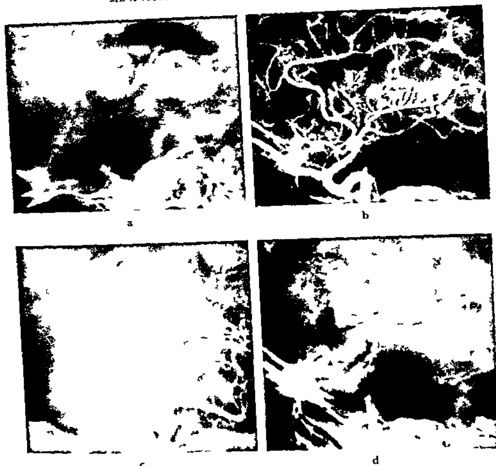
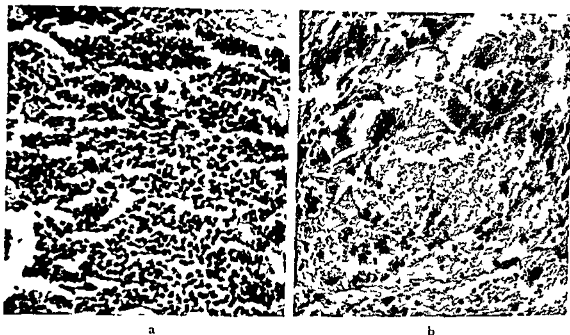


Fig 1 Case 1 a) Encephalography Small amount of air introduced via the lumbar subarachnoid route outlines a normal 4th ventricle the prepontine and interpeduncular cisterns are large and there is a suprasellar mass (the latter could be seen to better advantage in an autotomogram) b) Left carotid arteriography The anterior cerebral artery is elevated some small vessels are seen anterior to the supraclinoid carotid but cannot be definitely identified as arising from the cavernous carotid c) Frontal view Typical lateral deviation of the supraclinoid carotid with elevation of the horizontal portion of the anterior cerebral artery d) Left carotid arteriography venous phase Homogeneous contrast filling (tumor blush) in the suprasellar region some air remains in the frontal horns from the previous encephalographic examination e) Film obtained at about 18 seconds after the contrast medium injection Persistence of contrast medium the pituitary adenoma being outlined even more clearly although the venous phase had ended earlier



a b

Fig 2 Case I Photomicrograms showing cellular character of the tumor and the small sinusoidal capillaries (a) the edge of the tumor and large vascular channels filled with red blood cells (b) Magnification × 200 (Courtesy of Dr JAMES HARKIN,

Encephalography was performed It showed large prepontine and interpeduncular cisterns (Fig 1a) and a mass could be seen arising from the sella The posterior border of the mass was superimposed on the dorsum

In subsequent *carotid arteriograms* the supraclinoid portion of the carotid artery was displaced laterally and the anterior cerebral artery was elevated (Fig 1, b and c) Some prominent small arteries were seen in the anterior suprasellar region and tumor blush appeared in the venous phase of the angiogram (Fig 1d) The tumor was even more clearly defined in a film obtained approximately 10 seconds after the venous stage had ended (Fig 1e)

At surgery a reddish brown encapsulated slightly nodular mass was encountered medial to the right optic nerve When the frontal lobes were elevated the left optic nerve was exposed as it stretched laterally and superiorly over the midline mass There were numerous capsular vessels over the tumor surface The interior of the tumor was entirely solid and showed moderate vascular oozing A frozen section was reported as pituitary adenoma and it was elected to remove only that portion of the tumor superior to the diaphragma sellae together with its capsule Permanent sections verified the diagnosis of pituitary adenoma (Fig 2) with sinusoidal areas (RUSSELL & RUBINSTEIN 1963) and no unusual histologic features

Vision improved very rapidly after surgery and the patient was discharged on maintenance steroid therapy When last seen in the clinic five months following surgery her visual acuity was virtually normal in both eyes Menstruation had not resumed

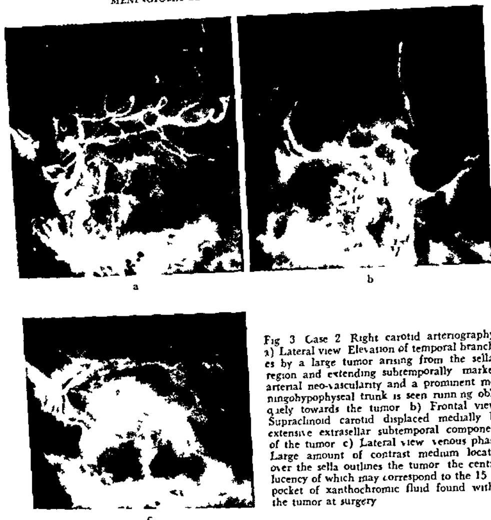


Fig 3 Case 2 Right carotid arteriography a) Lateral view Elevation of temporal branches by a large tumor arising from the sellar region and extending subtemporally marked arterial neo-vascularity and a prominent meningohypophyseal trunk is seen running obliquely towards the tumor b) Frontal view Supraclinoid carotid displaced medially by extensive extrasellar subtemporal component of the tumor c) Lateral view venous phase Large amount of contrast medium located over the sella outlines the tumor the central lucency of which may correspond to the 15 ml pocket of xanthochromic fluid found within the tumor at surgery

Case 3 A 41 year old man was admitted in June 1967 because of progressive loss of vision over the past year This was accompanied by personality changes and a tendency to sleep all the time About six months prior to admission he noted weakness in the left arm and leg There was no loss of hair or decrease in libido Physical examination confirmed the mild left hemiparesis and decrease in visual acuity with complete loss of the superior portions of both visual fields

On conventional roentgenography of the skull there was erosion of the dorsum sellae and sharpening of the anterior clinoids The brain scan showed a well-circumscribed round area of increased pick up measuring more than 3 cm in diameter centered over the sella extending to right



Fig. 4. Case 2. Photomicrogram of pathologic specimen shows a highly vascular fetal pituitary adenoma with a microfollicular pattern in some areas. Magnification × 50. (Courtesy of doctors J. Ziskind and E. McGarry.)

Right carotid arteriography (Fig. 3) disclosed a large extra axial mass with considerable arterial neovascularity and contrast filling in the venous phase. A presumptive diagnosis of parasellar meningioma was made and the patient was submitted to surgery.

At operation a portion of the right temporal lobe was resected exposing the nerve as it was elevated superiorly and stretched by a reddish mass. When the mass was aspirated through a small needle approximately 15 ml of xanthochromic fluid was obtained followed by a steady pulsatile flow of blood. As the temporal lobe was retracted further the mass could be seen to extend posteriorly and laterally. A portion of the tumor was removed for pathologic examination but because of brisk bleeding requiring transfusion of 2 500 ml blood, no further resection was made. Permanent pathologic sections (Fig. 4) revealed the tumor to be a highly vascular fetal pituitary adenoma (Russell & Rubinstein 1963). The patient was given radiotherapy postoperatively with a favorable response.

Case 3. A 55 year old man presented with severe headaches for 3 days before admission followed by onset of a right 3rd nerve palsy. Physical examination showed ptosis of the right eye and marked loss of visual acuity.

On routine skull examination a double floor of pituitary fossa was noted. The lateral view in right carotid arteriography (Fig. 5) showed a sellar and parasellar tumour with a



Fig 5 Case 3 Right carotid arteriography lateral view Slight staining with capsular accentuation (arrows) in the posterior portion of the tumor elevation of the anterior cerebral artery indicates presence of a large tumor mass more anteriorly though no angiographic blush was present in this portion.

contrast accumulation in its posterior portion On the permanent pathologic sections the tumor proved to be a combined chromophobic and eosinophile adenoma with large areas of necrosis and hemorrhage obscuring histologic details

Discussion

The blood supply to the pituitary gland varies somewhat in different mammalian species (HARRIS 1955) In man anatomical studies after post mortem injection of the internal carotid artery (MCCONNELL 1953 XUEREB, PRICHARD & DANIEL 1954a) have shown that branches of the internal carotid artery the superior and inferior hypophyseal arteries pass to the gland The former supply the area of the stalk the latter the posterior lobe The principal vascular supply of the normal anterior lobe is not arterial but venous by means of a portal system originating in the stalk (HARRIS 1955 XUEREB, PRICHARD & DANIEL 1945b) The systemic venous drainage of the normal adenohypophysis is to cavernous and intercavernous sinuses as well as to plexiform venous sinuses over the surface of the gland (GREEN 1957 WORTHINGTON 1962)

PARKINSON (1964 1965) has shown that the inferior hypophyseal artery arises from the internal carotid within the cavernous sinus as a branch of the

meningohypophyseal trunk This had earlier been demonstrated by SCHNURER & STATTIN (1963) who called this trunk artery the 'dorsal main stem It arises from the cavernous carotid posteriorly near the midline at, or just proximal to, the apex of the upward arch of the siphon According to PARKINSON's terminology there are two other branches of the meningohypophyseal trunk the tentorial and dorsal meningeal arteries There are anastomoses between the inferior hypophyseal and dorsal meningeal arteries on each side to form an arterial ring surrounding the base of the dorsum sellae

In 80 % of normal cases there is an additional branch of the cavernous carotid arising infero-laterally 0 5 cm more anteriorly This branch is named 'the inferior cavernous sinus artery' (PARKINSON) or 'lateral main stem (SCHNURER & STATTIN) Still further rostrad by a distance of 2 or 3 mm, one or two capsular arteries arise from the cavernous carotid (MCCONNELL 1953) In normal cases these are quite small and connect with each other across the midline over the superior surface of the gland near the stalk (PARKINSON)

Cavernous carotid artery branches can be identified on some normal arteriograms (PARKINSON 1964) Enlarged branches of the cavernous carotid have been found in a considerable variety of sellar and parasellar neoplasms, including, of course, pituitary adenomas (PRIBRAM, BOULTER & MCCORMICK 1966, WESTBERG & ROSS 1967, WALLACE, GOLDERG, LEEDS & MISHKIN 1967)

In Case 1 of the present report it was not possible to identify a definite branch of the cavernous carotid supplying the pituitary tumor Such vessels when present anteriorly, may be difficult to distinguish from anterior meningeal and ophthalmic artery branches or from overlapping branches of the anterior and middle cerebral arteries (SCHNURER & STATTIN) There was surgical evidence for increased capsular supply, as in the cases reported by WESTBERG & ROSS In our Case 2, however, a multitude of fine arteries supplied the body of the tumor, not just the capsular area These vessels did not appear to correspond to the normal arterial anatomy as described although there was also a prominent meningohypophyseal trunk running obliquely to the tumor from its origin in the cavernous carotid (Fig 3) The tumor blush in Case 3 was present only in a portion of the tumor posteriorly with well demarcated smooth margins *It is possible that* this was within an edematous or tumorous enlargement of the posterior lobe (HACKER & ALONSO 1968, DORON, BEHAR & BELLER 1965)

The occurrence of contrast density in a given portion of the angiogram at a certain phase indicates the presence of a larger amount of contrast medium per ml of tissue at that phase in the given angiographic region than in surrounding regions Contrast filling during the arterial phase implies increased arterial vascularity while filling during later phases suggests an increased relative percentage volume of capillaries and veins In the terminology of SAPIRSTEIN the former

contrast density is flow-determined while the latter is volume-determined In pituitary adenomas there may be a larger number of venous sinusoids within the tumor (Fig 2a) If these sinusoids are small enough and close together they are not resolved separately and the result is a more or less homogeneous contrast medium accumulation usually in the later phases of angiography The contrast may show capsular accentuation (WESTBERG & ROSS 1967) Those tumors such as in Case 2 with many feeding arteries demonstrable are more likely to be histologically atypical

Subtraction techniques are more sensitive than standard roentgenography and will pick up less marked differences in concentration of the contrast medium within the tumor as compared to adjacent tissues When accumulation of the contrast medium is prolonged, it is possible that contrast injections repeated at close enough intervals may have a somewhat additive effect in bringing out a tumor blush

Pituitary adenomas often show considerable local extension at times even involving the walls of the carotid artery, but true malignancy is rare (RUSSELL & RUBINSTEIN 1963) Clinical malignancy was noted by DORON & SCHWARTZ (1965) in their group of pituitary tumors showing the blush phenomenon In the present cases acceleration of clinical symptoms seems to have been associated with episodes of hemorrhage into the adenomas with consequent rapid growth of the lesions

Acknowledgement

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SUMMARY

Three cases of pituitary adenoma which on angiography showed a suprasellar meningioma blush are reported The basis for this phenomenon is discussed Awareness of the angiographic appearance may help to prevent confusion with meningioma when the clinical picture and conventional roentgen examinations otherwise point to pituitary adenoma

ZUSAMMENFASSUNG

Es wird uber drei Falle von Hypophysenadenom berichtet Bei Angiographie wurde eine suprasellare Kontrastmittelfullung demonstriert Beim Erkenntnis dieser Erscheinung kann eine fehlerhafte Diagnose von Meningiom vermieden werden wenn sowohl die klinische als auch die konventionelle Rontgenuntersuchung sonst auf die Anwesenheit eines Hypophysenadenoms hinweisen

RÉSUMÉ

Les auteurs présentent trois cas d'adénome hypophysaire avec opacification de méningiome supra sellaire Une meilleure connaissance de ce phénomene permettra d'éviter la confusion avec un méningiome quand le tableau clinique et la radiographie conventionelle font penser à un adenome hypophysaire

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FROM THE DEPARTMENT OF RADIOLOGY (DIRECTOR PROF G LOMBARDI), ISTITUTO NEUROLOGICO MILAN ITALY

OPHTHALMIC ARTERY IN AXIAL VIEW

by

G Lombardi and A Passerini

The whole length of the main trunk of the ophthalmic artery is radiographically visible in the axial projection of the skull although, owing to the superimposition of e g the middle cerebral arteries it is not always possible to distinguish all the collaterals The projection must often be slightly modified to allow a detailed study of the artery The subtraction technique is of great value as it has generally proved to be in cerebral angiographic examinations

The ophthalmic artery (Fig 1) arises from the supraclinoid part of the internal carotid artery and runs laterally, often at an acute angle towards the optic foramen the precanalicular or intracranial part cannot be identified in any view The artery enters the orbit via the optic foramen lateral to the optic nerve it then describes a loop around the nerve and runs a tortuous course in the vicinity of the medial orbital wall The lacrimal artery and supraorbital artery arise from the first intraorbital part and the loop of the ophthalmic artery The anterior and posterior ethmoidal arteries may also sometimes be identified (Lombardi & Passerini 1967)

The veins can be demonstrated in axial projections and the anatomical and topographic relationships between the superior ophthalmic artery and veins can be determined in such views (Fig 2)

The artery and the vein run close together anteriorly in the orbit where the

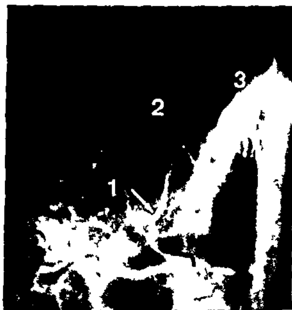


Fig 1 Axial view of skull Normal ophthalmic artery (intracranial part continuous line intracanalicular part dotted line intraorbital part arrow) Collaterals of the ophthalmic artery lacrimal artery (1) supraorbital artery (2) anterior ethmoidal artery (3)



Fig 2 Superimposition of the ophthalmic artery (black and marked by arrows) on the ophthalmic veins (white) The artery runs parallel to and outside the terminal part of the superior ophthalmic vein and then passes inside the loop described by the vein (top) In the lateral view (bottom) the ophthalmic artery lies between the superior and inferior ophthalmic veins



Fig 3 Angioma of the orbit verified at operation Aneurysm (arrow) of the intracranial portion of the hypertrophied ophthalmic artery

vein passes close to the trochlea, or pulley, of the superior oblique muscle the artery continues as the angular artery, and posteriorly, where the vein crosses the superior orbital fissure it passes into the cavernous sinus and enters the optic foramen The intermediate part of the artery which always lies on a lower plane runs medially to a loop described by the second and third parts of the ophthalmic vein



a



b

Fig 4 Meningioma of the fundus of the orbit a) The initial intraorbital part of the ophthalmic artery is displaced in a medial direction and its collaterals are stretched (arrows) b) Venous phase Accumulation of contrast medium in the tumour

The first part of the superior ophthalmic vein is anchored anteriorly to the superior internal angle of the orbit by the trochlea of the superior oblique muscle and runs to the roof of the orbit The second part courses from this point to the lateral wall of the orbit after passing under the superior rectus muscle while the third part runs inside the terminal part of the muscular cone to end in the cavernous sinus

Pathologic conditions Conditions demanding a study of the ophthalmic artery are rare, and so the observations are few, but still sufficient to justify some practical comments The axial projection of the skull permits a differentiation between intraorbital and intracranial lesions A typical example is an aneurysm of the first part of the ophthalmic artery, which is and behaves as a cerebral aneurysm (Fig 3) The axial view can complement doubtful or apparently negative angiographic data of the other views in new growths of the orbit (Fig 4) Lastly, it permits a closer analysis of the collateral vessels supplying such tumours as meningiomas of the sellar and suprasellar regions

SUMMARY

The course of the ophthalmic artery is described in detail from evidence obtained in axial views of the skull The usefulness of the substraction technique is stressed

ZUSAMMENFASSUNG

Der Verlauf der Arteria ophthalmica und ihre Darstellung besonders in den Axial projectionen wird beschrieben Der Wert der Subtraktionsmethode wird hervorgehoben

RÉSUMÉ

Les auteurs decrivent en detail le trajet de l'artere ophtalmique en se basant sur des angiographies en incidence axiale du crane Ils soulignent l'utilite de la technique de sous traction

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FROM THE DEPARTMENTS OF RADIOLOGY AND PATHOLOGY YALE UNIVERSITY SCHOOL OF MEDICINE NEW HAVEN CONNECTICUT U S A

EXPERIMENTAL PRODUCTION OF INTRACRANIAL VASCULAR LESIONS

Allylamine induced vascular lesions of the brain and intracranial infarction

by

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The basic morphologic changes of necrotizing arteritis associated with a wide variety of systemic diseases are characterized by fibrinoid necrosis of the media with cellular exudate involving the vessel wall and periadventitial tissues. The necrotizing arteritis produced by allylamine injury is characterized by intramural vascular hemorrhage nodular periarteritis proliferative endarteritis and fibrinoid necrosis (WATERS 1948 1954 1956) Although widespread coronary vascular lesions can be produced by intravenous injection of allylamine (BLOOR & LOWMAN 1963) localized arterial injury can be produced utilizing selective injection of the drug by means of transfemoral catheter techniques (LOWMAN & BLOOR 1963 LOWMAN HIPONA & VIDONE 1966) The general plan of this investigation has been to observe the effects of selective intra arterial injection of allylamine and to study the basic morphologic sequences of the lesions produced in the smaller injured intracerebral arteries The progressive manifestations characterizing the allylamine induced cerebrovascular lesions were evaluated by means of serial carotid or vertebral angiography These findings were then subsequently correlated with histopathologic studies.

Allylamine an unsaturated alphatic amine (CH2 ChCH2 NH2) is a toxic

substance identified in the tissues of animals dying of experimental paratyphoid infection which produces a marked increase in capillary permeability and edema of the vessel wall Allylamine was shown by EPPINGER et coll in 1934 to produce capillary damage MELLON and his associates (1935) shortly thereafter described proliferative endarteritis and nodular periarteritis at the site of intracutaneous allylamine injection in rabbits

WATERS (1956) initiated a series of studies on the pathogenesis of vascular disease and evaluated the effects of intravenously injected human plasma or plasma rich globulins on the basic morphologic sequences in canine coronary arteries *injured by allylamine* LOWMAN *and co-workers* (BLOOR & LOWMAN 1963, LOWMAN & BLOOR 1963, 1965), in the study of the arteriography of experimentally induced coronary arterial lesions following allylamine injury, assessed the capabilities of various radiographic techniques in the demonstration of these lesions In subsequent studies, selective unilateral renal artery injection of allylamine was employed in the production of experimental animal models for the evaluation of arteriography and other investigative procedures in the study of renal hypertension (LOWMAN, HIPONA & VIDONE) Previous attempts to produce selective injury of the arterial wall by allylamine, utilizing intra arterial catheterization techniques, were limited to the study of coronary and renal arteries In the present study an attempt has been made to produce localized intracranial arterial injury of the branches of the anterior and middle cerebral arteries and of the branches of the basilar artery system utilizing selective intra arterial catheterization techniques

Studies of cerebrovascular disease in experimental animals have tended to lag behind pathologic and anatomical investigations Frequently, these studies have served as confirmatory work after clinical impressions have been virtually accepted (ADAMS 1968) The limitations of previous studies should be stressed since most angiographic and pharmacologic studies have been completed in animals with little or no induced vascular disease in the cerebral blood vessels Moreover, *in previous studies in which generalized atherosclerotic lesions have been produced* in experimental animals few significant changes in the cerebral vessels were recorded (ROBERTS & STRAUS 1965)

To understand the problems and goals of the following studies it is necessary to review some of the methods previously utilized to produce experimental cerebral infarction and intracranial vascular disease (HANDA 1964, MEYER 1958 SUNDT *JR & WALTZ 1966) These have consisted of* ligation of individual arteries in the neck, craniotomy with occlusion of individual cerebral arteries (LOWMAN et coll 1966), and injection of varying types of foreign substances in the experimental animals *The injected materials have included* seeds sand, air, iron fillings, and stainless steel ballbearings

These embolization techniques have succeeded in producing lateralized focal infarction with varying degrees of success. Liquid vinyl acetate injected into one internal carotid artery has produced occlusion of this artery and other cerebral vessels (WHISNANT et coll 1954) The injection of homologous clots producing showers of emboli have yielded lateralized cerebral infarcts in approximately 75 % of the animals so treated

DENNY BROWN (1956) has utilised the technique of the abrupt distention of a cerebral vein following saline injection to produce hemorrhagic cerebral infarcts Other investigators have produced cerebral infarction utilizing air emboli followed by the delayed intravenous administration of adrenalin (WHISNANT et coll 1954)

Various authors have indicated that the production of cerebral infarction is influenced by the available collateral circulation the arterial hypertension, venous stasis and by the degree of temporary or complete occlusion of the cerebral artery involved It must be emphasized that the leptomeningeal anastomotic channels can on occasions form an effective collateral circulation following occlusion of a major cerebral artery In the present study, no specific attempt has been made to produce cerebral embolization rather an attempt has been made to produce specific lesions involving the arterial wall of the distal intracranial vessels

Material and Methods

Under intravenous anesthesia of pentobarbital sodium 30 mg/kg and chlorpromazine 1 ml/kg control blood pressures blood chemistry and baseline angiographic studies were undertaken in 20 adult mongrel dogs of both sexes and varying ages The average weight of the dogs was 12—15 kg and the dogs were estimated to be of 1 to 3 years of age Through a femoral cut-down a polyethylene tubing I 160 80 cm long was inserted into the femoral artery This catheter was manipulated under fluoroscopic guidance into the region of the vertebral artery or the common carotid artery A test injection of 1 to 2 ml Hypaque 50 % was completed in order to localize the catheter position Angiograms of the cerebrovascular system were obtained with 3 to 4 ml Hypaque 50 % injections using a Schonander film changer at a film speed of 3 films per second for five seconds. Frontal and lateral views were obtained and fluoroscopy was again performed under image amplification control to confirm the catheter position Allylamine 1 4000 solution was injected through the catheter at a dose of 1 ml kg The catheter was withdrawn and the surgical incision closed

The dogs were observed for any physical and neurologic defects after recovery

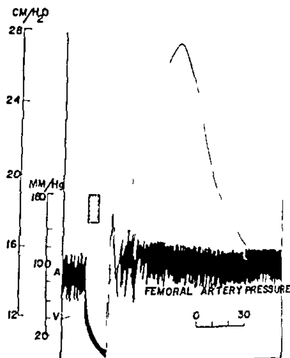


Fig. 1. *Diagram illustrating the measurement of systemic and cerebrovascular pressures following intracarotid injection of 4 ml Hypaque 50 % in anesthetized dog.* The femoral arterial pressure was measured in millimeters of mercury (scale in seconds). The intracranial venous pressure was measured in cm H_2O according to the technique of CANOSSI et coll. with catheter inserted via internal jugular vein.

from the anesthesia and at varying intervals thereafter. Repeated injections of allylamine were made in several dogs. Angiography was repeated prior to sacrifice of the animal for histologic correlation.

Allylamine, a strong base, was prepared for injection as an aqueous solution neutralized with hydrochloric acid and buffered to 7.4 pH. Buffered and unbuffered solutions were then employed.

Preformed red Kifa 160 polyethylene catheters of the open end type with no side holes were utilized for the injection. The catheters were approximately 80 cm in length, with an internal diameter of 1.2 mm. During the injection, monitoring was performed with lead II of an electrocardiogram on a Gilson polygraph recorder; this device also automatically registers the duration of the injection. Arterial blood pressures were measured by means of a Statham pressure transducer P 23 Db connected with a polyethylene catheter introduced into the aorta via the femoral artery. The intracranial venous pressure was evaluated by means of a water manometer connected with a polyvinyl catheter introduced into the external jugular vein and manipulated by way of the internal maxillary vein until the tip was as close as possible to the superior cerebral vein (CANOSSI et coll. 1962).

The cerebral circulation was calculated in two ways: first by evaluating the

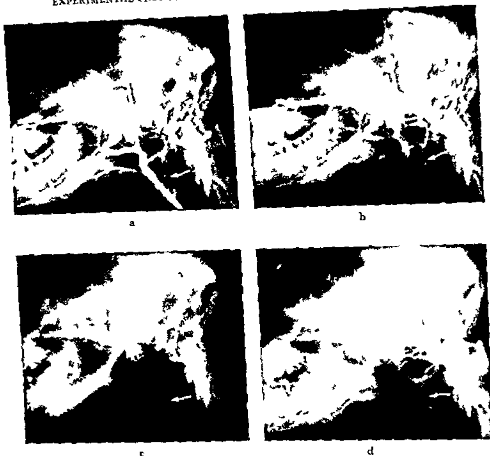


Fig 2 Common carotid arteriography by means of transfemoral catheterization 14 days following selective arterial injection of allylamine Stagnation and delayed wash-out in the internal carotid system a) Lateral projection immediately following the injection of 3 ml Hypaque 50 b) Delayed wash-out effect c) and d) Retention of contrast medium in the internal carotid system as compared to the external carotid circulation (arrows)

interval between the time when contrast medium was first seen in the internal carotid artery and in the deep cerebral veins a second estimation was completed by calculating the interval between the termination of visibility of the contrast medium in both these vessels (CAVOSSI et coll 1962 GREITZ 1956) This data will be reported in a subsequent paper

The aim of the preliminary studies was to establish the most suitable conditions for satisfactory demonstration of the intracranial vessels in order to study



Fig 3 a) Transfemoral common carotid arteriography 10 days following selective arterial injection of allylamine Bulbous dilatation of internal carotid origin and marked narrowing of the internal carotid artery distal to the dilatation This animal had multiple cerebral infarcts in the parietal and temporal lobe b) Lateral view obtained eight tenths of a second following injection Early venous filling with outlining of frontal vein (black arrows) ophthalmo cerebral vein and ascending cerebral vein The ascending cerebral veins (white arrow) were selected for demonstration of early venous filling since these vessels collect the blood draining the intracranial vessels *Other veins such as the cerebro facial and the internal maxillary veins* drain a significant portion of extracranial blood

the transit time following allylamine injury For this reason, no drug adjuncts were *utilized to alter the circulation and the distribution of the contrast medium* in the cerebral vessels (ARONSEN & NYLANDER 1966) It was noted that the administration of the contrast medium by way of the vertebral artery often provoked marked syncopal phenomena which often resulted in the death of the animal Therefore the carotid route was adopted in some of the later studies Injection of the contrast medium by the carotid route often induced a transient arterial hypotension followed by an increase in the intracranial venous pressure In several animals, however, angiographic evaluation of the vertebro-basilar system by means of selective arterial studies was completed (Fig 4)

In eleven animals clonic convulsions occurred at the time of the allylamine administration into the region of the left vertebral artery In one animal three episodes of convulsions were observed following the repeated injection of 4 *ml* aliquots of allylamine No convulsions were noted in this animal after saline or Hypaque 50 % injections into the same artery The transient convulsions involving both sides of the body were of short duration These convulsions lasted for approximately 10 to 15 seconds

In two animals with allylamine injured carotid vessels resulting in closure of these arteries aortic arch injections of 20 ml Hypaque 70 % produced sustained clonic convulsions which persisted for a period of 40 seconds In two animals weakness of the forelegs occurred 48 hours following selective catheter injection of allylamine in the intracranial vessels Because of the unstable gait one animal fractured his left foreleg This was splinted and the dog was further observed There was no change in appetite in any of the animals Other than the above observations most of the dogs remained in perfect condition

Roentgenologic findings

The angiographic anatomy of the cerebral circulation of the dog has been previously described and therefore only the morphologic data on which the serial angiographic evaluation of the intracranial circulation is based in this study will be considered (ARONSEN & NYLANDER 1966, BONAKDARPOUR et coll 1967, CANOSSI et coll 1962) The internal carotid and the ascending cerebral veins have been chosen as starting and ending points of the cerebral circulation The first can be recognized easily by its funnel shaped origin from the common carotid artery and by its course crossing the occipital and greater auricular arteries The ascending cerebral veins can be detected in the parietal area and are directed to the superior sagittal sinus. The ascending veins collect the blood from the intra cranial vessels This is in contrast to the veins situated anteriorly such as the cerebro-facial vein the internal maxillary and frontal veins which collect significant portions of extracranial blood (CANOSSI et coll)

It should be stressed that in the dog the great auricular, superficial temporal lingual and inferior alveolar arteries are more clearly outlined than the internal carotid system it is difficult to define the tributaries of the internal carotid system which was also the case in our group of animals In one instance thrombosis in the internal carotid artery was seen 2 weeks following the injection of allylamine there was definite stasis with delay in the passage of the contrast medium in the internal carotid system throughout the angiographic studies of this animal (Fig 2) In another dog severe narrowing of the internal carotid artery distal to the carotid bulb was demonstrated (Fig 3)

Except for delays in the transit time of the contrast medium, the demonstration of stasis effects with delayed wash-out of the contrast medium in the internal carotid system the retention of it in the vertebral artery system and early venous filling no appreciable anatomical changes were encountered in the angiographic studies before and after allylamine injection No localized mass effect or displacement of intracranial vessels were demonstrated



Fig 4 Selective percutaneous transfemoral catheterization of the left vertebral artery completed following previous selective allylamine injury Satisfactory contrast filling of the vertebral artery the ascending vertebral artery and the megalospinal circle No gross mass defect displacement diminished or abnormal vascularity could be seen Although widespread lesions are contained in the region of the left cerebellar hemisphere because of the placement of the catheter in the left vertebral artery no satisfactory evaluation of the stasis effect could be made No mass effect was demonstrated in the region of the left cranial hemisphere

Histopathologic correlation

The dogs were sacrificed from 4 to 14 days following selective allylamine injections of the common carotid or vertebral artery system Angiography was repeated in all animals prior to sacrifice for histopathologic correlation The brains were fixed in 10 % formalin for several days and then coronally sectioned Representative sections were processed for histologic study and were stained with hematoxylin — *eosin, thionine* (Nissl) and the Weil stain technique for myelin

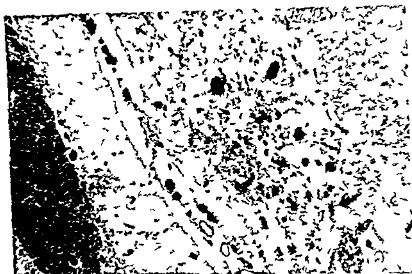


Fig 5 Section made 14 days following allylamine injection Focus of necrosis in cerebellar cortex with numerous dilated and congested blood vessels Hematoxylin and eosin ×35

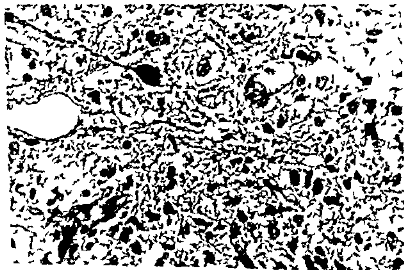


Fig 6 Section made 5 days following a single dose of allylamine injection Necrotic neuron are seen in a background of increased numbers of astrocytes and microglia Hematoxylin and eosin ×250

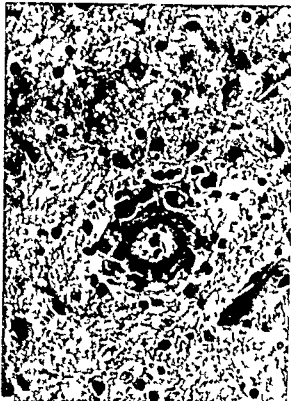


Fig 7 Section made 14 days following multiple allylamine injections Increased cellularity of small blood vessel wall which is also slightly thickened Hematoxylin and eosin ×250



Fig 8 Section made 21 days following multiple allylamine injections Thickened capillary surrounded by numerous gitter cells Hematoxylin and eosin ×250

The lesions following common carotid injection were generally confined to the anterior two thirds of the ipsilateral cerebral hemisphere, while those associated with the vertebral artery injection generally had a bilateral distribution, although predominantly ipsilateral The lesions following vertebral artery injury were observed in the tegmental portion of the pons and the medulla, the cerebellar cortex and subcortical white matter The lesions following injection into the vertebral and carotid systems were observed not only in the areas described above but also in the gyrus lateralis posterior and hippocampal formation

Extensive hemorrhagic involvement of the choroid plexuses was encountered in several cases Grossly, the parenchymal lesions appeared as focal zones of dull, gray, granular discolorations Macroscopic hemorrhages were rarely encountered Necrotic lesions (Fig 5), which could be characterized as both acute and subacute, were encountered, while most of these lesions were ischemic, some had a distinct hemorrhagic component

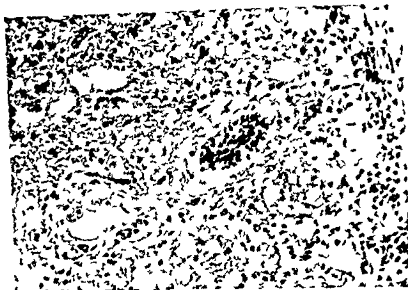


Fig 9 Thickened blood vessel with perivascular accumulation of *macrophages* and lymphocytes at edge of focus of subacute necrosis increased numbers of microglia and astrocytes are seen and a neuron undergoing *central chromatolysis* is present in the right upper quadrant Hematoxylin and eosin ×195

The typical acute ischemic focus of necrosis was located either *within the* cortex or white matter or in both the cortex and the immediate subcortical white matter The neurons in the affected regions which were sharply outlined from the surrounding intact tissue were undergoing *acidophilic necrosis* with pyknotic and eosinophilic cytoplasm Swelling of astrocytic nuclei was a prominent feature, and a generally slight to moderate increase in the number of astrocytes and microglia was seen (Fig 6) The oligodendroglia were uniformly pyknotic An occasional polymorphonuclear leukocyte was seen The blood vessels, arterioles capillaries and venules within and immediately adjacent to these foci generally showed increased cellularity of their walls (Fig 7) which were slightly thickened and occasionally partially hyalinized

In the subacute lesions varying numbers of lipid laden macrophages the gitter cells (Fig 8) were seen and the involved brain tissue was undergoing dissolution Blood vessels within these lesions were of appearances not unlike those seen in the acute lesions however small perivascular collections of lymphocytes and macrophages were present (Fig 9) A striking finding was the swelling of axons at the periphery of the subacute lesions involving the white matter These were

accompanied by a moderate increase in astrocytes and pallor suggesting demyelination

Fresh or recent hemorrhages were occasionally seen within or at the edge of the necrotic lesions, both acute and subacute Small fresh hemorrhages not associated with necrotic foci and with no apparent reaction in the surrounding brain tissue were also seen, as were small hemorrhages into the subarachnoid space, *choroid plexus, and ventricular system In one animal the presence of* pigmented macrophages and an increase in fibrous connective tissue within the choroid plexus were indicative of an older or organizing hemorrhage Varying numbers of lymphocytes were seen focally in the meninges of several animals and occasional perivascular collections of lymphocytes were seen in non necrotic regions In one animal, a dense nodular infiltrate of lymphocytes was found in the choroid plexus Focal anoxic change, characterized by a selective necrosis of the neurons of the Sommer sector of the Ammon s horn configuration with an accompanying increase in astrocytes, was noted in one animal

Discussion

The present study was undertaken to determine whether or not the progressive alteration characterizing allylamine induced vascular lesions could be demonstrated as structural abnormalities of the carotid and vertebral artery systems, utilizing various angiographic techniques The angiographic evaluation of the effects on the brain by diagnostic methods currently in use does not appear to be effective in detecting early and small vascular lesions following allylamine injury if criteria based on anatomic alterations alone are used

In the evaluation of the present group of animals by means of serial angiography, criteria similar to those utilized for the diagnosis of cerebrovascular disease in humans were employed Distinctive differential radiologic features have been set forth as criteria for the angiographic evaluation of the changes produced in cerebrovascular disease It must be stressed that while serial angiography may demonstrate angiographic findings essentially normal in character, a search should be made for the following features

1 Decreased velocity of flow with retention of contrast medium in the supply arteries, i e the stasis effect

2 Cerebral accumulation of contrast medium (capillary blush)

3 Early *venous filling*

4 Occlusion of supply arteries with irregularities in the caliber of the involved vessels

5 Local mass effects with displacement of vessels

Of the criteria enumerated the most constant hemodynamic alterations were (1) retention and stasis of the contrast medium in the proximal arterial circulation (2) early venous filling

These findings were encountered in 12 of the 20 dogs studied In none of the animals was a mass effect or capillary blush encountered The inability to demonstrate a capillary blush was considered significant despite the demonstration of significant capillary vascular proliferation surrounding the site of infarction

Depending on the size distribution and the appearance time these regions of vascular proliferation surrounding the sites of infarction may indeed account for varying capillary and venous circulatory changes in the angiogram These circulatory changes when demonstrable, can be of diagnostic value

Recently various authors have described unusual angiographic findings associated with derangement and loss of autoregulation of the cerebral circulation in acute cerebrovascular disease LASSEN (1959) and LASSEN (1963) indicated that the loss of autoregulation of the cerebral circulation in association with the luxury perfusion syndrome of the brain could be characterized by increased blood flow, reduced oxygen consumption and loss of the physiologic responses of the cerebral vessels to CO and blood pressure changes This syndrome may occur with focal brain ischemia and with hemorrhage and tumors The variations in blood flow in such cases have been shown by means of regional radioactive inert gas techniques as reported by CRONQVIST et coll (1966)

The proliferation of the small vessels as demonstrated by the sections described in the experimental animal may indeed account for the accumulation of contrast medium around the margins of the infarct and may also account for the shunting of the contrast to produce the early visibility of the draining vessels It serves to explain the variations in cerebral blood flow occurring in association with cerebral infarcts It is also important to note that occlusion of the small cerebral arteries may occur without radiologic evidence of cerebral ischemia Moreover gross occlusion in the vessels may not be demonstrable by means of routine angiographic techniques

Conclusion

The study of the allylamine induced vascular lesions with development of neurologic manifestations provides an insight to the mechanism of injury to the vessel wall and the effect of these changes in the brain The histopathologic studies thus far provide a mechanism for assessment of brain damage due to induced vascular lesions. The data obtained from animals receiving single injec

tions of allylamine and sacrificed at intervals from 24 hours to 14 days suggests the following sequence of events

The first change appears to be due to an injury to the endothelial portion of the arterial wall with focal necrosis of the intima and the inner portion of the media (WATERS 1948, 1954) As the vascular lesion progresses, a progressive fibrosis of the intima is associated with fibrous replacement of portions of the media and loss of segments of the internal elastica The injury to the vessel wall may be associated with non occlusive thrombus formation at the sites of intimal injury The end result of such acute injury is the diminution in size of the vascular lumen

In animals receiving multiple injections of allylamine, the sequence of events appears to be the same With repeated injury, however, the extent and the severity of the vascular changes are increased Transudation of plasma through the damaged endothelium, leading to stasis in the vessel and the adjacent tissue, apparently occurs focally There are varying degrees of ischemia of the cerebral cortex, associated with incomplete or selective necrosis of neurons and foci of complete necrosis, mostly ischemic, but occasionally hemorrhagic In general, the severity of the parenchymal and vascular involvement appeared to be determined by the dose of allylamine given

Cerebrovascular disease in the experimental animal should resemble as closely as possible the clinical situation in humans In order to satisfy this the following criteria must be adhered to in the production of the cerebrovascular disease

1 Induction of the cerebrovascular disease in the experimental animal should be completed without surgical intervention involving the brain or the adjacent dural coverings

2 The dural envelop should remain intact This will prevent artificial de compression of any accompanying cerebral edema which is produced by the allylamine vascular injury

3 Manipulation of vessels other than the one which is injured to produce cerebral changes should be kept to a minimum

4 The intracerebral changes should be produced without significant blood loss or hypotension

The non surgical technique of selective cerebral artery injection of allylamine in the intact animal satisfies these criteria

The present study provides an experimental model for the evaluation of cur rent diagnostic radiologic techniques and the appraisal of various pharmacologic aids in the study of the effect of these chemicals on the cephalic vessel reactivity It provides a model for the development of improved radiologic techniques for appraisal of the induced lesions The present model also provides a mechanism for an understanding of the pathogenesis of some types of cerebral infarction

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SUMMARY

Selected intra arterial injection of allylamine into the cerebral arteries of dogs affords a relatively simple method for studying the pathogenesis and fate of cerebral vascular lesions Some of the lesions produced are basically similar to those occurring in certain diseases of man The early lesions represent endothelial and subintimal reactions followed by losses of portions of the elastica and associated with proliferative fibroblastic reaction and reduction of the lumina of the vessels Changes in the neuroglia and regressive neuronal changes occur and there is infarction of the brain The size and location of the intracranial changes vary probably due to differences in the anatomical arrangement of blood vessels and in the amount of blood flowing through collateral channels

ZUSAMMENFASSUNG

Durch selektive intra arterielle Injektion von Allylamin in die cerebralen Arterien von Hunden konnen cerebrale Gefassveranderungen pathogenetisch relativ einfach studiert werden Prinzipiell sind einige der hervorgerufenen Schadigungen denen ahnlich die bei gewissen Erkrankungen des Menschen auftreten Die fruhen Schaden bestehen aus endothelialen und subintimalen Reaktionen, worauf Verlust von Teilen der Elastica folgt und sind mit einer proliferativen fibroblastischen Reaktion und Verminderung des Gefasslumens verbunden Veranderungen der Neuroglia und regressive Veranderungen der Neuronen sind ebenso wie Hirninfarkte vorhanden Die Grosse und die Lokalisation der intracranialen Veranderungen wechseln wahrscheinlich als Folge unterschiedlicher anatomischer Verhaltnisse der Blutgefasse und der Blutmenge die durch kollaterale Gefasse stromt

RÉSUMÉ

L injection intra artérielle sélective d allylamine dans les artères cerebrales de chiens constitue une méthode relativement simple pour etudier la pathogenie et l evolution des lésions vasculaires cerébrales Certaines des lésions produites sont semblables à celles qui existent dans certaines affections humaines Les lesions précoces sont des réactions endotheliales et sous intimales suivies de la disparition de certaines portions de la tunique élastique et associees à une réaction proliférative fibroblastique et a une reduction de la lumière des vaisseaux Il apparait des lesions de la neuroglie et des lesions regressives des neurones et il y a un infarctus cérébral La dimension et le siege des lesions intracraniennes varient probablement en raison des differences de la disposition anatomique des vaisseaux sanguins et des quantités de sang circulant à travers les vaisseaux collateraux

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ELECTROENCEPHALOGRAPHIC AND ELECTROCARDIOGRAPHIC STUDIES OF COMPLICATIONS IN CEREBRAL ANGIOGRAPHY

by

ARNE LUNDERVOLD and ARNE ENGESET

Cerebral angiography is not yet considered a completely innocuous procedure as complications both transient and permanent, may occur Contrast media have therefore been tested and neurologic and cardiovascular reactions occurring during this diagnostic procedure have been investigated The effects on the electroencephalogram in human subjects as well as in laboratory animals were studied by FOLTZ and coworkers (1952) who found either an immediate generalized flattening of the electrical activity or homolateral production of new activity INGVAR (1957) INGVAR & SODERBERG (1957) and GREITZ & WEISS (1959) on the other hand have reported few changes in the EEG when moderate doses of contrast media were injected Cardiovascular reaction occurring in conjunction with carotid angiography have been described by many authors HEINRICH & KESSEL (1940) BROMAN & OLSSON (1948), HALGE 1954) GREITZ (1956 1966) LUNDERVOLD (1957) LINDGREN & TORNELL 1958) KÅGSTROM LINDGREN & TORNELL (1958 1960) FISHER (1961 1962 1965 1967) AMUNDSEN (1965) LINDGREN SALTZMAN & TORNELL (1968) In order to clarify both the circulatory effect and the brain wave changes occurring with different contrast media during cerebral angiography in human

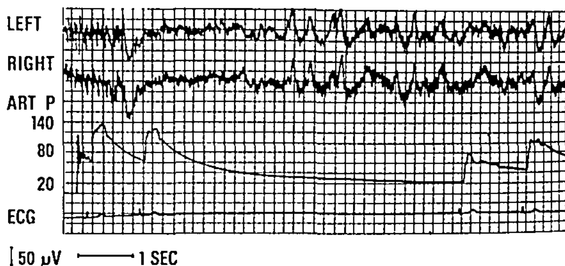


Fig 1 Carotid angiography (sodium metrizoate 10 ml) with asystole for 6 seconds and distinct fall in blood pressure with bilateral EEG changes The upper two tracings demonstrate electrical brain activity over the left and right frontoparietal regions The third tracing represents the intraarterial pressure in the common carotid artery the lower tracing is the ECG record

subjects, investigations have also been performed in our laboratory (LUNDERVOLD, SKRAASTAD & BORGERSEN 1963, LUNDERVOLD & ENGESET 1966, 1967)

Material and Methods The authors have made polygraphic recordings in an additional 700 patients, making a total of 1 000 patients since the earlier report at the 7th Symposium Neuroradiologicum in New York 1964, which dealt with the first 300 patients, this means about 3 000 injections of contrast media The complications were recorded electroencephalographically, electromyographically, electrocardiographically and by measurements of the intraarterial and sometimes of the intraspinal pressure as well The respiration was also recorded in many patients

The following contrast media, all containing 290 mg I/ml were studied Isopaque Cerebral (M 98 1 Ca 1 9), Isopaque (Na 92 0/Ca 4 7/Mg 3 3) and Urografin 60 % (Na 13 M 87) Hypaque and sodium metrizoate were also examined in the first study of 300 patients Injections of 8 to 10 ml contrast medium were made percutaneously or through a catheter into the common carotid artery or vertebral artery Local anesthesia was used in most of the patients but under special circumstances general anesthesia was employed

The comparison as a rule was made between two different contrast media with saline as a control in each patient The sequence of injections of the two contrast solutions and a similar amount of saline was randomized to exclude any effect from the order of injections

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$T_5 O_1$

$O_1 O_2$

$O_2 T_6$

$T_6 T_4$

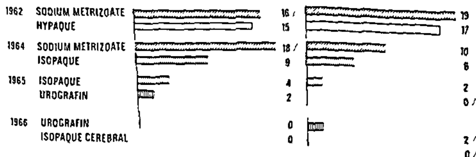
$F_3 P_3$

$F_4 P_4$

ECG

50 μV 1 SEC

Fig. 2. Ten seconds after right side carotid angiography (sodium metrizoate 10 ml) producing focal right side EEG changes with accompanying transient paresis of the extremities contralaterally. The upper two tracings are recorded from the left temporal and occipital region and the sixth from the left frontoparietal region, all indicating normal or nearly normal activity. The other tracings reveal abnormal slow wave activity from the same regions of the left hemisphere.



Figs 3 and 4. ECG changes (left diagram) and EEG changes (right diagram) during cerebral angiography. Influence of type and amount of contrast medium, effects of premedication with atropine and of measures undertaken to reduce an increased intracranial pressure to normal level.

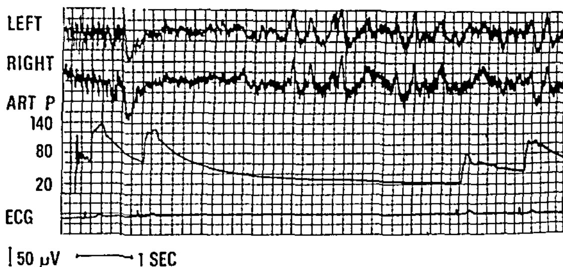


Fig 1 Carotid angiography (sodium metrizoate 10 ml) with asystole for 6 seconds and distinct fall in blood pressure with bilateral EEG changes The upper two tracings demonstrate electrical brain activity over the left and right frontoparietal regions The third tracing represents the intraarterial pressure in the common carotid artery, the lower tracing is the ECG record

subjects, investigations have also been performed in our laboratory (LUNDERVOLD, SKRAASTAD & BORGERSEN 1963, LUNDERVOLD & ENGESET 1966, 1967)

Material and Methods The authors have made polygraphic recordings in an additional 700 patients, making a total of 1 000 patients since the earlier report at the 7th Symposium Neuroradiologicum in New York 1964, which dealt with the first 300 patients, this means about 3 000 injections of contrast media The complications were recorded electroencephalographically, electromyographically, electrocardiographically and by measurements of the intraarterial and sometimes of the intraspinal pressure as well The respiration was also recorded in many patients

The following contrast media, all containing 290 mg I/ml were studied Isopaque Cerebral (M 98 1/Ca 1 9), Isopaque (Na 92 0/Ca 4 7/Mg 3 3) and Urografin 60 % (Na 13/M 87) Hypaque and sodium metrizoate were also examined in the first study of 300 patients Injections of 8 to 10 ml contrast medium were made percutaneously or through a catheter into the common carotid artery or vertebral artery Local anesthesia was used in most of the patients but under special circumstances general anesthesia was employed

The comparison as a rule was made between two different contrast media with saline as a control in each patient The sequence of injections of the two contrast solutions and a similar amount of saline was randomized to exclude any effect from the order of injections

$T_3\ T_5$

$T_5\ O_1$

$O_1\ O_2$

$O_2\ T_6$

$T_4\ T_4$

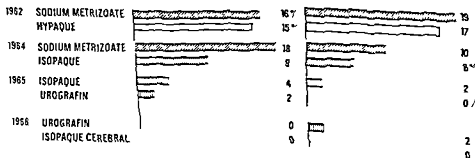
$F_3\ P_3$

$F_4\ P_4$

ECG

50 µV —— 1 SEC

Fig. 2 Ten seconds after right side carotid angiography (sodium metrizoate 10 ml) producing focal right side EEG changes with accompanying transient paresis of the extremities contralaterally. The upper two tracings are recorded from the left temporal and occipital region and the sixth from the left frontoparietal region all indicating normal or nearly normal activity. The other tracings reveal abnormal slow wave activity from the same regions of the left hemisphere



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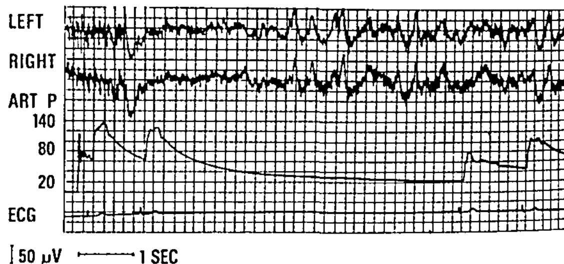


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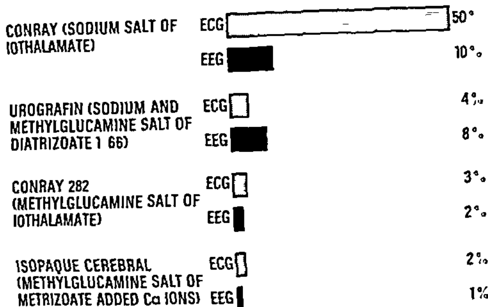


Fig 6 Minor EEG and ECG abnormalities recorded during cerebral angiography in the last year (1967 369 injections) Such abnormalities as those recorded in Figs 3 and 4 were not present at this time These minor changes were not accompanied by clinical signs

This improvement seems to be due to different factors Techniques have improved and the patient receives atropine (0 6 mg) as premedication Increased intracranial pressure occurring in the presence of intracranial expanding lesions has been reduced by means of mannitol (60 to 70 ml of a 15 % solution in 20 minutes) The amount of contrast medium has been reduced from 10 to 7 ml and the number of injections have been cut down by obtaining films in two planes simultaneously The decrease in radiographic complications is probably mainly attributable to the fact that improved contrast media have been available

This improvement is evident from the ECG tracings during periods shown in Fig 3 Hypaque and sodium metrizoate produced marked changes in 15 % to 16 % of the patients in 1962 Isopaque in 1964 reduced the abnormalities in the tracings to 9 % and in the following year to 4 % mainly because of a reduction in the amount of contrast medium injected from 10 to 7 ml The first methylglucamine salt was introduced in 1965 and produced marked changes in the tracings in only 2 % No marked abnormalities were observed with Urografin or Isopaque Cerebral in 1966

The same improvement is evident in the EEG tracings of Fig 4 With the introduction of Isopaque marked changes could be recorded in only 2 % of the

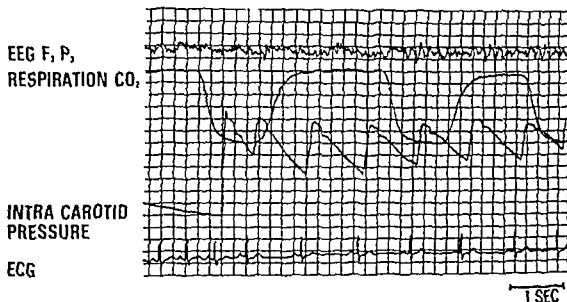


Fig 5 Carotid angiography with Isopaque and during general anesthesia The EEG in the upper tracing shows a few slow waves the respiration rate in the next tracing has increased and the pulse pressure diminished The bottom line in the ECG indicates some bradycardia These minor changes were not accompanied by clinical signs

Results

The effect of contrast media may be recorded in two ways The first is the influence on the heart Bradycardia or asystole may occur, prolonged asystole may result in unconsciousness The second effect is upon the brain and may be recorded by means of the electroencephalogram Focal changes in the EEG tracing may, if long lasting be accompanied by transient or permanent paralysis of the extremities contralaterally

Injection of a contrast medium produces marked changes in the electrocardiogram (Fig 1) The heart stopped for 6 seconds in one patient, the asystole being followed by a marked fall in blood pressure, slow waves were produced in the EEG tracing when the patient became unconscious The injection of contrast medium into the right carotid artery in another patient (Fig 2) led to marked changes in the EEG tracing on the same side as the injection The slow waves were recorded some time before the patient became hemiparetic

These two examples are from the first period, in recent years such marked abnormalities have not been recorded Since the previous meeting in New York the incidence of complications recorded from the brain and the vascular system has steadily been diminishing Among the last 200 patients, the electroencephalographic and electrocardiographic changes as well as blood pressure changes have been reduced to less than 5 % compared to about 35 % before



Fig 8 Arrangement with the ele trode box on the roentg n table and application of the el ctrodes on the head of the patient for the EEC recording and on the extremities for the ECG registration

The examination is now simple and not time consuming The arrangements of the equipment and especially the application of the electrodes on the head and the electrode box on the roentgen table are shown in Fig 8

SUMMARY

Recordings of EEC ECG and intra arterial blood pressure during cerebral angiography performed in 1 000 patients have revealed a marked reduction in the last sixteen years in the occurrence of abnormaliti s This is probably due to improvements in contrast media Complications during cerebral an iography are now probably due to other factors such as the form of an sth sia used

ZUSAMMENFASSUNG

Laufend Kontrolle der EEG und FCG und des intra arteriellen Blutdruckes bei cerebraler Angiographie an 1 000 Patienten haben eine deutliche Verminderung von schadlichen Einflu sen wahrend den letzten 16 Jahren gezeigt Dies ist wahrscheinlich d n verbes erten Kontrastmitteln zuzuschreiben Zwischenfalle bei der cerebralen Angiographie sind heute mehr durch andere Faktoren wie z B die Narkose bedingt

RÉSUMÉ

L enregistrement de l EEG de l ECG et de la pression sanguine intra arterielle au cours d l angiographie cérébrale chez 1 000 sujets a montre une importante diminution de la frequ nce des anomalies de ces enregistrements au cours des seize dernières annees La raison principale est probablement l amelioration des moyens de contraste Les complications au cours de l an iographie cérébrale doivent maintenant etre plus souvent dues a des facteurs tels que l anesthésie plutot qu au moyen de contraste lui meme

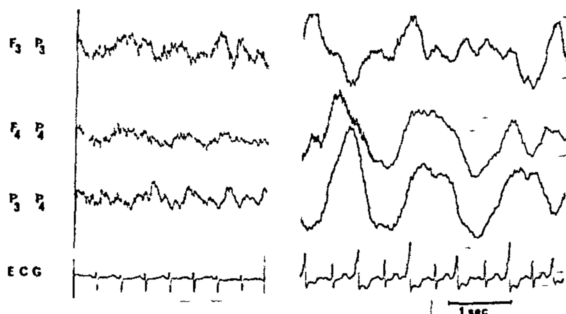


Fig 7 Normal EEG and ECG recordings during general anesthesia (left part of diagram) and abnormal tracings during intubation before carotid angiography (right part of diagram) The upper tracings represent the left frontoparietal region the second tracings are from the right frontoparietal region and the bottom line is the ECG record

patients in 1965 Isopaque Cerebral and Urografin gave even better results During this year no marked changes were produced but only minor abnormalities in the tracings, unaccompanied by clinical signs Fig 5 indicates that the injection of contrast medium may produce slight changes in the EEG tracing an increase in respiration rate, lowering of the pulse pressure and evidence of bradycardia in the ECG tracing These minor abnormalities were not accompanied by any clinical signs

The results from last year (1967) are given in Fig 6 and disclose only minor changes in the tracings The diagram shows clearly that the methylglucamine salts are superior to the sodium salts Fewer changes in the tracings have been encountered with Isopaque Cerebral than with Urografin or Conray 282 The contrast media have now been improved to such an extent that complications during cerebral angiography may more often be caused by factors other than the medium itself

The marked EEG and ECG changes produced by intubation in general anesthesia are demonstrated in Fig 7 All these complications have occurred in the polygraphic recordings during routine angiographic examinations, and necessary precautions, when possible, have been taken It would therefore appear that polygraphic recordings are of practical value in routine angiographic work

FROM THE METHODIST HOSPITAL, TEXAS MEDICAL CENTER HOUSTON TEXAS U S.A

ANGIOGRAPHY OF CEREBRAL MYCOTIC ANEURYSMS

by

DAY MCNEEL ROBERT A EVANS and EDWIN M ORY

Neurologic complications occur in 20 to 25 % of patients with bacterial endocarditis (5 8) These can be classified into four groups (1) ischemic lesions resulting in focal neurologic signs (2) abscess formation (3) meningeal reaction, and (4) cerebral mycotic aneurysm formation with or without intracranial hemorrhage In spite of the use of antibiotics cerebral mycotic aneurysms occur in approximately 3 to 4 % of patients with bacterial endo arditis (1 7) Approximately 4 % of cerebral aneurysms are of mycotic origin (3 4)

Cerebral mycotic aneurysms in bacterial endocarditis are attributed to the lodgement of infected emboli in the lumen or the vasa vasora of the cerebral vessels with resultant infection of the vessel wall As inflammatory destruction of the ve sel wall particularly the elastic tissue weakens the wall aneurysmal dilatation occurs If the destruction is rapid perforation may occur before the vessel has had time to yield and free hemorrhage without aneurysm formation can occur Mycotic cerebral aneurysms are often quite small and distally located on the cerebral arterial tree and are easily overlooked at autopsy unless post mortem angiograms are obtained

The medical records of eleven patients with bacterial endocarditis and cerebral mycotic aneurysms have been reviewed In eight patients cerebral angiograms were obtained and repeated angiographic studies were available in four patients

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The medical histories and angiographic findings in three of the patients will be described briefly.

Case reports

Case 1. A 38 year old female was admitted with a 1 week history of fever and malaise and a 1 day history of confusion and dysphasia. On physical examination there was a systolic cardiac murmur, an expressive dysphasia and slight weakness of the right arm. Blood cultures grew alpha hemolytic streptococcus. The spinal fluid contained 2,360 white blood cells (83% polymorphonuclear leukocytes); the sugar content was normal and the spinal fluid culture was negative.

The patient was treated with antibiotics. A right hemiplegia developed 5 days after admission and left carotid angiography was performed at that time (Fig. 1a). An aneurysm of 3 mm diameter was present on a small branch of the left callosomarginal artery with an adjacent zone of cerebral swelling. In addition, a second larger aneurysm was seen at the proximal left middle cerebral artery at the point of its first major branching (Fig. 1b) with occlusion of the major branch of the middle cerebral artery from which the aneurysm arose.

Several days after the initial angiography, when the patient's speech disturbance and hemiplegia had improved, bilateral carotid angiography was repeated and showed an increase in size of the aneurysm at the small anterior parietal convexity branch of the left callosomarginal artery (Fig. 1c). No other significant changes were noted.

A third carotid angiography performed 10 days after the second showed a definite decrease in size of the aneurysm at the left parietal vertex. The patient was discharged 8 weeks after admission with slight weakness of the right leg as the only neurologic deficit.

Case 2. A 17 year old female was admitted with a 4 week history of fever and left hemiparesis. The patient had undergone surgical repair of an atrial septal defect 10 months before. On the day of admission the patient developed transient speech difficulty and became lethargic and disoriented. A systolic cardiac murmur was present. Six days after admission the patient developed left sided headache, blurred vision and papilledema.

Bilateral carotid angiography was performed and a left temporal lobe mass was observed. In addition a 5 mm in diameter saccular aneurysm of a peripheral branch of the right pericallosal artery was present (Fig. 2a).

Craniotomy was performed and a left temporal intracerebral hematoma was evacuated; the source of the hematoma was not ascertained. The patient was treated with antibiotics.

Repeat bilateral carotid angiography 9 days after operation revealed a considerable decrease in size of the aneurysm at the right hemisphere (Fig. 2b).

When the patient was discharged the neurologic examination was within normal limits.

Case 3. A five year old female was admitted with a 1 day history of two generalized convulsions and vomiting. There was a history of rheumatic fever 8 months previously. On physical examination the patient was obtunded and febrile. There was a systolic cardiac murmur, papilledema, right hemiparesis and bilateral extensor plantar responses. Blood cultures grew an alpha hemolytic streptococcus.

Left carotid angiography revealed a saccular aneurysm 7 mm in diameter at the superior aspect of the left midparietal convexity and arising from a peripheral branch of the middle cerebral artery. A contiguous cerebral mass was present (Fig. 3). A second discrete focus of

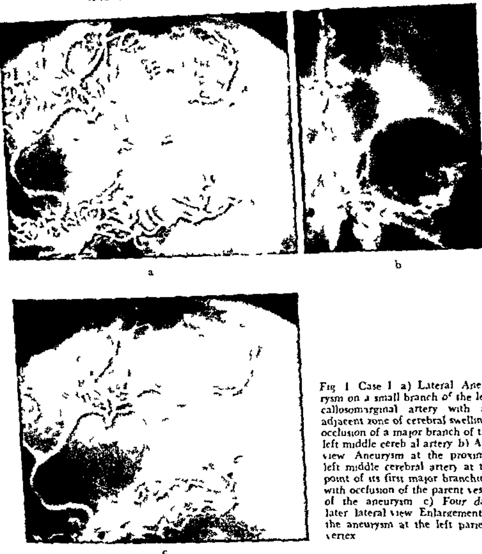


Fig 1 Case 1 a) Lateral Aneurysm on a small branch of the left callosomarginal artery with an adjacent zone of cerebral swelling occlusion of a major branch of the left middle cereb al artery b) A p view Aneurysm at the proximal left middle cerebral artery at the point of its first major branching with occlusion of the parent vessel of the aneurysm c) *Four days* later lateral view Enlargement of the aneurysm at the left parietal vertex

c r bral swelling was present superior to the midportion of the left sylvian fissure and was associated with occlusion of one of *the ascending* frontoparietal branches of the middle rebral artery

A left parietal craniotomy was performed for removal of an intracerebral hematoma and th mycotic aneurysm Micros opic examination of the surgical specimen howed an artery terminating in a mass of inflammatory *tissue with fra*'mentation of the internal elastic lamina and neutrophilic cellular infiltration Bacteriologic cultu e of this tissue grew alpha hemolytic streptococcus The patient was treated with antibiotics

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Fig 3 Case 3 Aneurysm arising from the left middle cerebral artery at the superior aspect of the left midparietal convexity There is an expansive lesion around the aneurysm and another one superior to the midportion of the left Sylvian fissure one of the ascending frontoparietal branches of the middle cerebral artery is absent

of the involved artery In the present series occlusion of the parent vessel occurred with three of the nine aneurysms demonstrated by angiography whereas spasm was noted once only The embolic origin of the mycotic aneurysms might account for the relatively high incidence of occlusion of the parent vessel in the absence of vasospasm Repeated angiography has demonstrated that mycotic aneurysms can increase or decrease in size rapidly in days or weeks without accompanying change in the patient s clinical status Spontaneous obliteration has been demonstrated also (1) Mycotic cerebral aneurysms are usually single Swelling about the aneurysms is common and may be attributed to encephalitis infarction or hematoma alone or in combination Multiple occluded arteries might be seen in topographically separate segments of the cerebral arterial tree indicating an embolic process and providing a clue to underlying bacterial endocarditis Mycotic aneurysms often have a narrow neck which may account for any prolonged and incomplete outlining with contrast medium of the lumen of the aneurysm

SUMMARY

Cerebral mycotic aneurysms occur in 3 to 4 % of patients with subacute bacterial endocarditis These aneurysms are usually located distally on the cerebral arteries at branches of the middle cerebral artery in particular Repeat angiography might show rapid changes

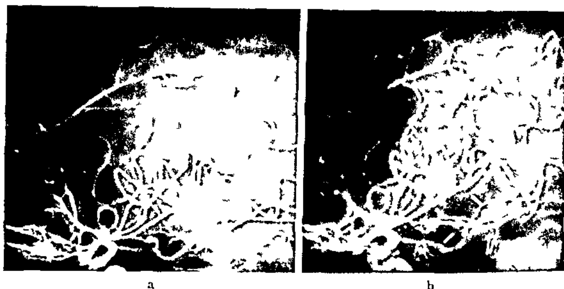


Fig 2 Case 2 a) Aneurysm on the right pericallosal artery The aneurysm has a small neck and the lumen of the aneurysm is incompletely filled with contrast medium b) Nine days later Marked decrease in size of the aneurysm

Bilateral carotid arteriography was repeated 10 days after surgery then no evidence of aneurysm formation was noted The patient was discharged 2 weeks after admission with slight right sided weakness and mild dysphasia

Discussion

The ages of the eleven patients with cerebral mycotic aneurysms ranged from seven months to 78 years Blood cultures grew an alpha hemolytic streptococcus in four patients, *staphylococcus aureus* in two patients, *proteus morgani* in one patient and *candida albicans* in one patient Blood cultures were sterile in two patients Four patients died and the diagnosis was confirmed at autopsy in all four In only one patient (Case 1) were multiple intracranial aneurysms found In one patient, a mycotic aneurysm of the popliteal artery was present as well as the intracranial mycotic aneurysm

Cerebral mycotic aneurysms are usually located at peripheral hemispheric arterial branches The middle cerebral artery is most commonly involved, including its proximal division, which is a common site for congenital aneurysms, also However, mycotic aneurysms occur rarely in the region of the anterior communicating artery or the internal carotid artery, which are common sites for congenital cerebral aneurysms

In congenital aneurysms occlusion of the parent vessel is unusual, and commonly is due to prolonged and severe arterial spasm which leads to thrombosis



Fig ? Subintimal injection and extravasation of the contrast medium No lesion of the arterial walls one month later

a sufficient amount will reach the cerebral arteries. The mean duration of the arterial phase at a rate of 2 films second is roughly the same as after injection into the carotid artery and the venous phase appears at the same interval Variations in the calibre of the arteries are offset by varying the quantity of contrast medium to be injected

The results obviously differ depending on the side of injection and the anatomical arrangements of the arteries at the base of the neck In the event of insufficient filling of the cerebral vessels a second injection is necessary in order to fill the subclavian, and where required the innominate artery and the aortic arch (Fig 1)

For assessing the accuracy of the investigation we used as standard of com-



Fig. 1. Simultaneous bilateral retrograde brachial injections: frontal and lateral views. The anterior spinal artery is marked with an arrow.

guide to overcome the tortuosity of the vessel, according to the technique proposed by BERGSTRAND for carotid angiography. We inject about 0.6 ml/kg of one of the routine tri-iodate contrast media (Conray or Hypaque 60 % or 50 %) with a Gidlund automatic syringe at a pressure of 2 to 6 kg/cm according to the age, build, body weight, and arterial pressure of the subject. We never use a greater amount than 60 ml contrast medium per injection. In younger children, 12 to 15 ml are injected with an ordinary Record hand syringe.

The brachial artery may be punctured at points other than at the inner aspect of the elbow but cannulation may then prove more difficult. Injection of the radial artery at the pulse yielded cerebral angiograms of poor contrast, probably because of the longer distance the medium had to travel.

The advantages of simultaneous biplane filming by the single injection technique are obvious. The greater part of the medium injected enters the aorta but

Fig 4 Midline angioreticuloma Comparison between left (lower view) and right (upper view) vertebral injection

extravasations varying in degree with the skill of the operator It was realised at the outset that the percentage of unsatisfactory angiographies was on the high side Roentgenograms of the arm were therefore obtained with a portable set during the injection These disclosed that a varying degree of subintimal seepage had occurred in 10 % of the patients and in some had reached the armpits, this percentage has now markedly decreased The patients were checked by oscillometer but were found to have no variations from the normal When angiography was again performed films of the arm revealed no lesions of the arterial walls (Fig 2) A bandage with slight compression was applied after the investigation which prevented the appearance of any large hematomas it should be noted that thrombosis may be caused by undue compression During the search for and puncture of the artery the patient may experience transitory paresthesia of the hand and forearm Puncture lesions of the median nerve or



Fig. 3. a) Local narrowing of the proximal segment of the right vertebral artery. b) Thrombosis of the right common carotid artery. c) Thrombosis of the basilar artery: the upper end of the artery is defined by posterior communicating arteries.

parison the percentage of cases in which certain arteries selected as samples were identifiable in the films. It was impossible to take into consideration all the intracranial branches of the carotid and basilar arteries. The data obtained for the ophthalmic artery do not differ much from those reported by TARTARINI & GIUGNI (97 %); for the anterior choroid artery they were slightly lower than those of SJOGREN (94 %) and for the left inferior cerebellar artery they were slightly higher than those of KRAYENBUHL & YASARGIL (88 %).

For evaluating complications arising at retrograde angiography of the brachial artery, the same criteria and the same classification as used recently in a study of over 2 000 carotid angiographies were employed (PASSERINI, BOLPONI & CECCHINI 1966). No fatal accidents or general complications of a cardiovascular character were encountered. Urticarial reactions occurred in a few instances but these gave no cause for concern and they cleared up without treatment. However, two major neurologic complications arose, both in patients after right brachial angiography performed under general anesthesia: these were psychomotor agitation accompanied by a sensory and motor hemisyndrome and homonymous hemianopia on regaining consciousness. The symptom complex receded gradually and disappeared completely within 5 to 6 days.

The only complications of any interest at the injection site were periarterial

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permanent changes of tone or sensitivity were never observed Only four patients still complained of pain at the site of puncture fifteen days after the investigation

Brachial angiography is a valuable aid for the diagnosis of intracranial lesions, vascular disease, and tumours of the cervical spinal cord and spine (Figs 3 and 4) Percutaneous retrograde injection of the right brachial artery is also an alternative method of demonstrating the right carotid artery in certain local conditions (tracheotomy, goitre, thrombosis) and yields fuller information on the development of sellar and parasellar tumours as well as of growths impinging on the tentorium

Left brachial injection outlines the vertebrobasilar system alone Many techniques of vertebral angiography have been described, but spasm of the vertebral or basilar arteries during injection, or failure to effect direct puncture of the vertebral artery, may make their demonstration difficult Direct puncture of diseased arteries increases the hazard of neuroradiologic procedures In an effort to eliminate these drawbacks we have lately been practising vertebral angiography *solely by brachial approach Right brachial and left carotid angiography may* be performed under local anesthesia in a single session and provide an overall view of the entire cerebral circulation The need for general anesthesia is thus eliminated, *an important consideration in large neuroradiologic centers* where the number of patients requiring exploration of the whole cerebral circulation is steadily increasing

SUMMARY

Percutaneous puncture and retrograde injection of the brachial artery is described in detail with reference to 700 angiographies The method is a valuable aid in the diagnosis of intracranial lesions vascular disease and tumours of the cervical spinal cord

ZUSAMMENFASSUNG

Auf Grund der Erfahrungen an 700 durchgeführten Angiographien wird die perkutane *Punktion der Bronchialarterie und deren retrograde Injektion* besprochen Die Methode ist wertvoll für die Diagnose intrakranialer Tumoren Gefässveränderungen und Geschwülsten des oberen Rückenmarkes

RÉSUMÉ

Les auteurs décrivent en détail la ponction percutanée et l'injection rétrograde de l'artère humérale en se basant sur *700 angiographies qu'ils ont faites par* cette technique Cette méthode paraît utile pour le diagnostic des lésions intracraniennes pour les affections vasculaires et les tumeurs de la moelle cervicale



Fig 1 A p pneumogramme et a p phlebogramme indicant le parallelisme complet entre la largeur du ventricule cerebral lateral et la distance entre la veine thalamo-striee et le plan sagittal

l angiographie carotidienne auxquels ont ete soumis parallelement 179 malades — dont 92 avec un systeme ventriculaire normal et 87 avec une hydrocephalie interne acquise — à des degres divers et d origine differente Nous obtenions les phlebogrammes en face au moyen d un rayon roentgenographique central, entrant par glabella et perpendiculaire au film Il a ete etabli qu il existe un parallelisme complet entre la largeur du ventricule lateral et la distance entre la veine thalamo-striee et le plan sagittal (Fig 1) Comme point de repere a servi celui du plan sagittal le plus eloigne situe sur la veine thalamo-striee L accroissement de cette distance est proportionnel a la dilatation ventriculaire

Sur la base de cette regularite il a ete mesuree chez tous les malades d une part la distance entre le plan sagittal et la veine thalamo-striee et d autre part celle entre le plan sagittal et la table interne du crane au meme niveau (Fig 2) Les valeurs absolues qui ont ete obtenues nous ont permis de dresser des relations et de deduire des index phlebographiques a titre d orientation determinant le degre de la dilatation ventriculaire comme suit

1	Largeur ventriculaire normale	+4 0
2	Dilatation ventriculaire legere	4 0—3 5
3	Dilatation ventriculaire modérée	3 5—3 0
4	Dilatation ventriculaire massive	—3 0

Par ailleurs nous avons soumis les malades presentant une hydrocephalie a une etude comparative en ce qui concerne les diverses phases et projections de l angiographie carotidienne en serie notamment pour savoir dans quelle mesure

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DETERMINATION ANGIOGRAPHIQUE DU DEGRE DE LA DILATATION ACQUISE DES VENTRICULES CEREBRAUX LATERAUX

par

J. PETROV

Le diagnostic classique de l'hydrocephalie interne acquise est base surtout sur les resultats de l'examen pneumographique. Les indications elargies de l'angiographie carotidienne, cependant, ainsi que l'application de celle-ci en tant que *premiere methode contrastante d'analyse chez la majeure partie des malades*, imposent non seulement le discernement angiographique exact de la dilatation acquise des ventricules cerebraux lateraux, mais aussi la determination du degre de cette dilatation.

En somme, le tableau angiographique bien connu de l'hydrocephalie, decrit deja par MONIZ *(1934)* et enrichi par maints d'autres auteurs (*1, 3, 5, 6, 7, 8, 9,* 13, 16, 18, 20), etait fonde naguere surtout sur les modifications de la phase arterielle. Ce n'est que ces dernieres annees que certains auteurs (1, 4, 10, 12, 17, 19, 21, 22, 23) ont accorde une attention speciale aux données de la phase veineuse de l'angiographie carotidienne, temoignant d'une dilatation du ventricule cerebral lateral. *On a propose, a cet effet, aussi quelques methodes* radiometriques pour la determination phlebographique du degre de la dilatation (2, 14, 15).

Partant de ces faits prealablement etablis, nous avons procede a des recherches comparatives des a. p. pneumogrammes et des phlebogrammes en face de

de tels signes on etablit souvent a l age enfantin (sur le phlebogramme en face pneumographiquement, par voie operatoire ou moyennant l autopsie) un systeme ventriculaire normal

Les resultats de nos recherches nous permettent d aboutir à la conclusion suivante la projection en face de la phase veineuse de l angiographie carotidienne est d une grande importance pour le diagnostic angiographique de la dilatation acquise des ventricules cerebraux lateraux Sur cette projection sont manifestees aussi bien la dilatation ventriculaire precoce initiale, legere que l hydrocephalie massive interne En outre le phlebogramme en face permet la determination directe par voie radiometrique du degre de la dilatation ventriculaire

RÉSUMÉ

Sur ba e des mesures effectuees sur les phlebogrammes en face de l angiographie carotidienne chez 179 malades on deduit à titre d orientation des indexes phlébographiques determinant le degre de la dilatation ventriculaire D autre part en comparant les donnees des diverses phases et projections de l angiographie carotidienne en serie on etablit qu aux fins du diagnostic angiographique de l hydrocéphalie interne acquise le role le plus important revient au phlebogramme en face

SUMMARY

On the basis of measurements in frontal phlebograms obtained at carotid angiography in 179 patients phlebographic indices were derived for orientation by which the degree of ventricular dilatation could be determined It was also found in a comparison of the information contained in different phases and projections at serial carotid angiography that the frontal phlebograms are most helpful in the angiographic diagnosis of acquired internal hydrocephalus

ZUSAMMENFASSUNG

An Hand von Messun en von frontalen Phlebogrammen, die bei Karotisangiographien von 179 Patienten gewonnen wurden wurden phlebographische Masse aufgestellt mit deren Hilf der Grad einer Ventrikel Dilatation bestimmt werden kann Es wurde ebenfalls gefunden da s verglichen mit der Information die man aus verschiedenen Pha en und Projektionen bei einer Reihen Karotisangiographie erhalt die frontalen Phlebogramme am nutzlich ten fur die angiographische Diagnose des erworbenen Hydrocephalus internus sind

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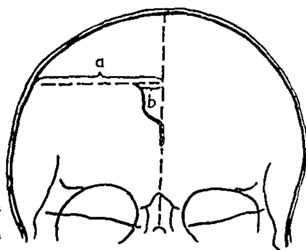


Fig. 2. Détermination de l'index phlébographique d'orientation $I_{ph} = \frac{a}{b}$
a = distance entre le plan sagittal et la tabula interna du crâne
b = distance entre le plan sagittal et la veine thalamostriée

chaque projection d'une phase donnée contient les signes de dilatation du ventricule cérébral latéral. Les résultats de cette comparaison donnent la fréquence de la manifestation du syndrome hydrocéphalique lors des diverses phases et projections de l'angiographie carotidienne chez 87 malades avec hydrocéphalie interne acquise.

Phases et projections de l'angiographie carotidienne	Manifestation du syndrome hydrocéphalique (nombre des cas)	%
1. Phase artérielle		
Profil	55	63
Face	47	54
2. Phase veineuse		
Profil	37	42
Face	87	100

Il ressort de ces résultats que la dilatation ventriculaire est perçue sur la projection en face de la phase veineuse dans tous les cas (100 %) et en un pourcentage sensiblement inférieur sur les autres projections et phases. Ceci concerne *surtout les hydrocéphalies acquises d'un degré léger ou moyen.*

Nos investigations montraient, en outre, qu'il n'existe pas un parallélisme complet entre la largeur ventriculaire réelle et la manifestation de signes de la dilatation ventriculaire que l'on perçoit sur les projections latérale et en face de la phase artérielle et la projection de profil de la phase veineuse. Ceci est observé surtout chez les individus âgés, chez qui les modifications des vaisseaux cérébraux dues à l'âge avancé et à l'athérosclérose, masquent parfois les signes de la dilatation ventriculaire réellement existante. Par contre, malgré la présence manifeste

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HAMODYNAMIK DER SACKFÖRMIGEN ARTERIELLEN ANEURYSMEN

von

E PIRKER und H E DIEMATH

Im Krankengut der Neurochirurgischen Abteilung und der Radiologischen Universitatsklinik Graz wurden 70 % aller sackformigen zerebralen arteriellen Aneurysmen an der Außenseite von Gefaßkrummungen gefunden Demnach scheint neben den anlagebedingten Gefaßwandschwachen an den bekannten Pradelektionsstellen und dem Anprall der Pulswelle sicherlich auch die Fliehkraft des Blutstromes fur die Ausbildung solcher Aneurysmen von Bedeutung zu sein Diese Fliehkraft ist dabei umso großer je kleiner der Krummungsradius des Gefaßes ist

Rontgenkinematographische Untersuchungen eignen sich besonders gut folgende drei Fragen in allen Einzelheiten zu beantworten

1 Wie erfolgt die Auffullung von Aneurysmen deren Große das 3—5 fache des Durchmessers des Elterngefaßes nicht uberschreitet?

2 Werden durch die Blutzirkulation in solchen Aneurysmen die hamodynamischen Verhaltnisse im Elterngefaß verandert und wenn ja in welchem Ausmaße?

3 Ist die Auffullung solcher Aneurysmen abhangig von der Korperlage des Patienten?

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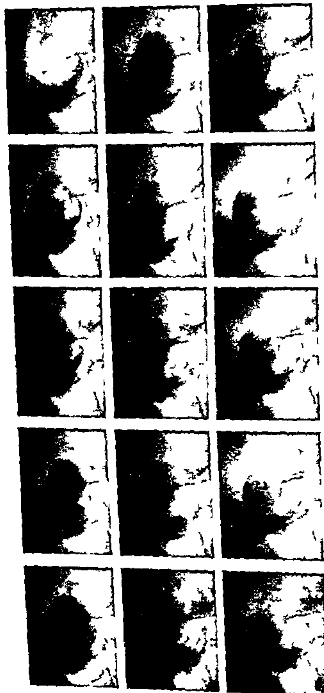


Abb. 2. Walnußgroßes Aneurysma der A. carotis interna. Anprall der Strömung und heftige Wirbelbildung an der e n n Aneurysmawand und Zone geringer Wirbelbildung sind gut abgrenzbar



Abb 1 Aneurysma der A carotis interna Ausschnitt aus Kinematogramm zur Darstellung von Füllung und Entleerung des Aneurysma

Im Modellversuch wird bei Aneurysmen, die dem Elterngefaß seitlich anliegen, nur der Randstrom fur die Durchblutung des Aneurysmas in dieses abgelenkt Der abgezweigte Strom prallt an der in Stromrichtung gelegenen Aneurysmawand auf und es kommt zur Bildung eines großen Wirbels im

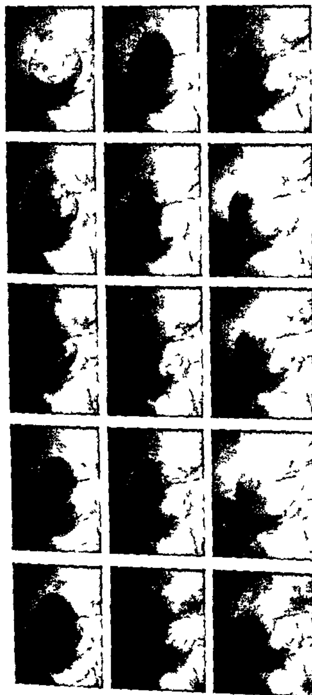


Abb. 9. Walnußgroßes Aneurysma der A. carotis interna. Anprall der Strömung und heftige Wirbelbildung an der einen Aneurysmawand und Zone geringer Wirbelbildung sind gut abgrenzbar

Aneurysma. Der aus der Randzone des Elterngefäßes abgeleitete Blutstrom ist bei Aneurysmen, deren Durchmesser das 3—5fache des Elterngefäßes nicht überschreitet, so gering, daß die Strömung im Elterngefäß so gut wie nicht vermindert wird. Eine Wirbelbildung im Elterngefäß konnte im Strömungsmodell nicht beobachtet werden.

Die *Röntgenkinematographie* zeigt uns deutlich, daß bei Aneurysmen, die den oben definierten Bedingungen entsprechen, ein allmählicher Austausch von Aneurysmablut mit kontrastmittelbeladenem Blut stattfindet. Inzwischen ist im Elterngefäß der Kontrastmittelstrom schon weiter in die Peripherie fortgeflossen. Dieser zeitliche Unterschied des Austausches des Aneurysma-Inhaltes wird aber noch deutlicher bei der Entleerung des Aneurysmas, welche dem Durchstrom des Kontrastmittels im Gefäßsystem oft lange nachhinkt. Die röntgenkinematographischen Untersuchungen machen weiters deutlich, warum ein Aneurysma auch bei *offenem Lumen angiographisch übersehen werden kann*, dann nämlich, wenn die Kontrastmittelmenge im Elterngefäß nicht ausreicht, um in der zur Verfügung stehenden Zeit von der Randzone aus das Aneurysma aufzufüllen.

Besondere Beachtung schenkten wir der dritten Frage, ob die Körperlage des Patienten einen Einfluß auf die Hämodynamik im Aneurysma habe. Hier zeigt sich, daß sich Aneurysmen in allen Einzelheiten unabhängig von der Körperlage völlig gleich auffüllen. Diesem Befunde kommt nicht nur theoretische Bedeutung zu. Bei einem Aneurysma, dessen hämodynamische Belastung stark von der Körperlage abhängig wäre, müßte dies bei einer neurochirurgischen Operation auch in der Lagerung berücksichtigt werden.

Die ganze Vehemenz der Strömung in einem Aneurysma wird aber besonders deutlich, wenn ein Aneurysma Walnußgröße oder mehr erreicht. Hier sind die hämodynamischen Verhältnisse der Wirbelbildung besonders gut sichtbar. Es ist deutlich zu erkennen, wie das einströmende Blut von der Aneurysmawand *aufgefangen wird. Diese in Stromrichtung gelegenen Wandabschnitte* scheinen am meisten beansprucht, hier kommt es auch sehr häufig zu Rupturen. An der gegenüberliegenden Aneurysmawand ist der Druck wesentlich geringer. Hier kann die Thrombusbildung beginnen. Bei einem so großen Aneurysma sind allerdings die hämodynamischen Verhältnisse wesentlich verändert. Einerseits dadurch, daß der Hohlraum des Aneurysmas einen Großteil des Blutstromes verschluckt und es nur mehr zu einer geringen Auffüllung der Peripherie kommt, andererseits wirken aber solche Aneurysmen bereits raumfordernd und drücken auf die Umgebung. Hierdurch erfolgt eine weitere Beeinflussung des Blutstromes im Elterngefäß und der Umgebung. Eine echte Kontrastmittelunterschichtung tritt auch bei derart *großen Aneurysmen nicht ein*. Dieses Phänomen konnten wir nur bei schlauchförmigen, englumigen Aneurysmen beobachten.

Wir wissen, daß die röntgenkinematographischen Untersuchungen zwar für die Routinediagnostik von zerebralen Aneurysmen nicht erforderlich ist, bei sehr kleinen sogar versagen kann, glauben aber dadurch wesentliche Informationen über ihre Hämodynamik zu erhalten

ZUSAMMENFASSUNG

Mit Hilfe der Röntgenkinematographie kann die Strömung in arteriellen Aneurysmen untersucht werden Die kleinen Aneurysmen zeigen eine typische ihnen eigene Hämodynamik die die Strömung im Elterngefäß nicht wesentlich beeinflußt Monstrose Aneurysmen lassen hingegen gut die verschiedenen Wirbelzonen abgrenzen zufolge ihrer Größe saugen sie aber einerseits die Masse des angebotenen Blutes in sich auf und behindern andererseits durch Kompression die Zirkulation in die Peripherie

SUMMARY

The blood flow in arterial aneurysms can be studied by means of cineroentgenography Hemodynamically small aneurysms have their own proper characteristics and the blood flow of the parent vessels is not materially affected In large aneurysms on the contrary the different whirl zones can be well delimited due to their size the aneurysms absorb on the one hand all the blood supplied and on the other hand by compression hinder the peripheric circulation

RÉSUMÉ

La radiocinématographie permet d étudier la circulation dans les anévrysmes artériels Les petits anévrysmes ont une hémodynamique typique qui leur est particulière et qui n influe pratiquement pas sur la circulation dans le vaisseau sur lequel ils sont implantés Les anévrysmes volumineux permettent au contraire de bien délimiter les différentes zones tourbillonnaire en raison de leur volume d une part ils aspirent la masse de sang qui arrive et d autre part font obstacle par compression à la circulation dans la périphérie

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THE DEVELOPING BRAIN

Correlation between radiologic and anatomical findings

by

D G Potts, G T Svare and R T Bergeron

Some of the most difficult diagnostic problems encountered by the neuroradiologist are those seen in the newborn or infant Even after careful investigation with pneumography and angiography it may be difficult to form an accurate picture of the anatomy of the brain In many abnormal cases it may be uncertain whether the changes represent a true congenital anomaly, disease acquired in utero, or damage caused at the time of birth

Relatively few infants have been subjected to these investigations in the first few months of life and most of those studied have had grossly abnormal brains Our knowledge of the normal radiographic anatomy of the newborn is therefore less complete than in older patients

There have been a number of detailed studies of the normal fetal brain (Weed 1917, Streeter 1918, Padget 1948, 1957, Yakovlev 1962), but much of the information is in a form that is difficult for the radiologist to utilize It was therefore felt that it might be of value to use radiologic techniques to study the fetal brain and to correlate the findings with conventional dissection and sectioning techniques

Radiologic methods have given valuable information about the detailed nor



Fig 1 Frontal view of a 10 cm fetus The external carotid branches are relatively large when compared with the internal carotid artery



Fig 2 Lateral view of a 8 cm fetus Internal carotid arteries had an almost straight course from the point of entry into the base of the skull to the supraclinoid region

mal anatomy of the cisterns (LILIEQUIST 1959) the arteries (SJOGREN 1956 GALLOWAY & GREITZ 1960 GREITZ & SJOGREN 1963 KAPLAN & FORD 1966 WOLLSCHLAEGER & WOLLSCHLAEGER 1966) and the veins (JOHANSON 1954) in adults but these methods have been used very little to investigate the fetal brain SUZUKI et coll (1966) briefly described the injection of fetal arteries but no roentgenograms were included in this report

Material and Methods The arteries veins ventricles and subarachnoid spaces of 32 dead fetuses the products of human abortions were injected with a barium gelatine contrast material (LINDBLOM 1950) and high resolution roentgenograms were obtained Dissections were then made with the aid of a dissecting microscope or the fetal heads were sectioned in the horizontal coronal or sagittal plane The fetuses studied had crown rump measurements of 5 5 to 17 centimeters which corresponded with gestation periods of approximately 3 to 5 5 lunar months

Arteries were filled by inserting a small catheter into the aorta, common or internal carotid artery and warm contrast material was injected very slowly under fluoroscopic control The veins were filled by a similar technique but



Fig 3 Lateral view of a 17 cm fetus The curves of the internal carotid arteries in the parasellar region are similar to those seen at maturity

with the catheter in a jugular vein or at the confluence of the lateral sinuses In order to demonstrate the intracranial subarachnoid spaces, the lumbar subarachnoid space was exposed by dissection and a small catheter was inserted in it as far up as the high thoracic region The contrast material was injected under fluoroscopic control Occasionally the aqueduct, and the third and fourth ventricles were filled by this technique, but when the ventricles were not filled, a lateral ventricle was punctured in the atrial region to permit direct injection into the ventricular system

Results

Arteries The external carotid artery and its branches were relatively large (Fig 1) in comparison with the internal carotid artery There was usually a minor degree of enlargement of the internal carotid artery in the position of the *carotid sinus* As the internal carotid artery passed from its point of entry into the base of the skull to the point where it was opposite the anterior clinoid process, its course was almost straight in the smaller fetuses studied (Fig 2) but in the larger fetuses included in this series it had the curves seen at maturity (Fig 3)

The internal carotid artery beyond the anterior clinoid process and the inferior part of the pericallosal artery of the smaller fetuses followed an almost straight course as far as the genu of the corpus callosum when seen in lateral projections but in the larger fetuses had a downward convexity at the anterior communicating artery In frontal projections the anterior communicating artery was high The branches of the pericallosal arteries on the medial aspects of the cerebral hemispheres lay close to the midline as there were no sulci at this stage



Fig 4 Frontal (a) and lateral (b) views of 10 cm fetus In the frontal view the middle cerebral branches show a minor change of direction as they pass over the edge of the slight depression of the sylvian fissure In the lateral view the branches of the middle cerebral artery are almost straight

For the same reason the more peripheral branches of the anterior, middle and posterior cerebral arteries on the convexity of the cerebral hemisphere had straight courses and lay close to the inner table of the skull

Because the sylvian fissures of the smaller fetuses were very shallow the middle cerebral arteries curved out in frontal projections to be quite close to the inner table of the skull as they lay on the surface of the insula (Fig 4a) In lateral views (Fig 4b) the branches of the middle cerebral arteries in this region in the smaller fetuses were straight or showed only a slight change in direction as they passed beyond the slightly depressed insula The middle cerebral arteries were high in lateral projections In the larger fetuses included in this study the middle cerebral branches on the surface of the insula had a configuration similar to that seen in young infants as the insula was buried under the opercula at this stage

The posterior communicating artery was nearly always large but the proximal part of the posterior cerebral artery was frequently small Because the choroid plexuses in the lateral ventricles were large the anterior and posterior choroidal arteries were large (Fig 5)

There was generally symmetrical development of both vertebral arteries and



Fig 5 Lateral view of 7 cm fetus Anterior choroidal artery relatively large



a



b

Fig 6 Frontal (a) and lateral (b) views of 11 cm fetus The basilar artery is in the midline and the vertebral arteries are symmetrical The superior cerebellar arteries are double on both sides



Fig 7 Rupture of middle cerebral artery branches with leakage of contrast material into the sylvian fissures on both sides

the basilar artery was near the midline (Fig 6) When the cerebellar arteries were filled it was seen that the superior and the anterior inferior cerebellar arteries were prominent but the posterior inferior cerebellar artery was small, reflecting the relatively undeveloped lower portion of the cerebellum at this stage The anterior spinal artery was occasionally seen

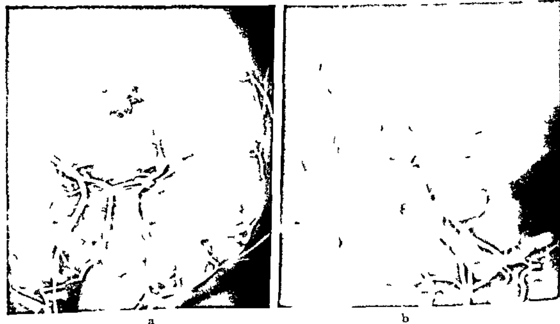
In spite of the very low speed of injection of contrast material rupture of the vessels sometimes occurred before the small peripheral arteries were well filled (Fig 7)

Veins An example of satisfactory filling of veins is shown in Fig 8 In some cases it was impossible to achieve satisfactory filling usually because the veins contained firm blood clots In these cases the venous anatomy was studied by dissection The internal cerebral vein was relatively large and the choroidal vein was prominent in the younger fetuses The petrosal sinuses and the inferior longitudinal sinus were small There were usually 4 to 6 major stems by which the superior cerebral veins entered the superior sagittal sinus and these veins entered the superior sagittal sinus at right angles The torcula was high in position in the younger fetuses

Ventricles The lateral ventricles particularly the atrial portions were relatively large and the brain substance thin These features are clearly shown in a horizontal section of the brain (Fig 9) The fourth ventricle was posteriorly situated reflecting the relatively large brain stem and small cerebellum The choroid plexus in the lateral ventricle appears as a simple fold projecting into



Fig 5 Lateral view of 7 cm fetus Anterior choroidal artery relatively large



a b

Fig 6 Frontal (a) and lateral (b) views of 11 cm fetus The basilar artery is in the midline and the vertebral arteries are symmetrical The superior cerebellar arteries are double on both sides

the ventricle at about 6 weeks (KAPPERS 1937) and by the second half of the third month the choroid plexus has grown to occupy almost the whole lateral ventricle By 4 months it begins to decrease in size in relation to the lateral ventricle

Cisterns The posterior fossa cisterns were reliably outlined by injecting the spinal subarachnoid space but the supratentorial cisterns were frequently not completely demonstrated Tomography was sometimes required to analyze the complex anatomy when the cisterns and ventricles were both contrast filled The spinal subarachnoid space was small due to the relatively large cord The subarachnoid space behind the lower cerebellum was wide because the lower portion of the cerebellum was small Frequently no cisterna magna could be recognized—the subarachnoid space extended over the whole posterior aspect of the cerebellum (Fig 10) In the supratentorial region the subarachnoid space was smooth on its inner and outer aspects because there were no secondary sulci at this stage The first secondary sulci to appear are the Rolandic fissure the parieto-occipital fissure the calcarine fissure and the collateral fissure which are seen at 6 to 7 months Cisternal filling gave a clear picture of the formation of the sylvian fissure with the brain in situ In the smaller fetuses studied here the sylvian fissure formed only a very slight depression on the lateral aspect of the brain while in the larger fetuses the insular region was buried by the opercula



Fig 11 Contrast filling of the vertebral veins (arrows)

An incidental finding was that the vertebral veins became contrast filled (Fig 11) in one case

Discussion

This study has established satisfactory techniques for the radiographic demonstration of arteries veins ventricles and posterior fossa subarachnoid spaces of dead fetuses down to about 5.5 centimeters crown rump measurement The method of contrast filling of vessels is most likely to be successful in fresh fetuses



Fig 8 Lateral view of fetus Contrast filling of the deep veins and the major venous sinuses as well as of the arteries



Fig 9 Horizontal section of the brain and skull showing the large atria and the slightly depressed developing sylvian fissures



Fig 10 Satisfactory contrast filling of the supra tentorial and the infratentorial subarachnoid spaces as well as of the fourth ventricle

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as formalin fixation causes hardening of clots within the vessels, making their demonstration more difficult The supratentorial subarachnoid spaces were not always completely filled by the method described here and other techniques are now being tested in attempts to demonstrate these more reliably

Most of the embryologic literature is devoted to fetuses smaller than those now described but there are many important changes that take place in the brain, its vessels, its ventricles and its subarachnoid spaces, after the third month It is hoped that this method of investigation will prove useful for the investigation of abnormal fetuses

Acknowledgement

This work was supported in part by NINDB NIH Special Fellowship 2F11 NB 1518 02

SUMMARY

Techniques for achieving contrast filling of vessels ventricles and subarachnoid spaces of fetuses with a crown rump measurement of 5 5 cm or larger are described The findings in the arteries are reported and the venous ventricular and cisternal changes summarized

ZUSAMMENFASSUNG

Die Verfahren bei Kontrastfullung der Gefasse Ventrikel und Subarachnoidalraume bei *Fotusse von 5 5 cm Hohe oder mehr werden behandelt Es wird uber die Befunde in den* Arterien und die venosen ventrikularen und zisternalen Veranderungen berichtet

RÉSUMÉ

Les auteurs decrivent des techniques pour remplir avec un moyen de contraste les vaisseaux les ventricules et les espaces sous arachnoidiens de foetus mesurant 5 5 cm du vertex au siege ou de foetus plus grands Ils decrivent l aspect des arteres et de façon sommaire les aspects des veines des ventricules et des citernes

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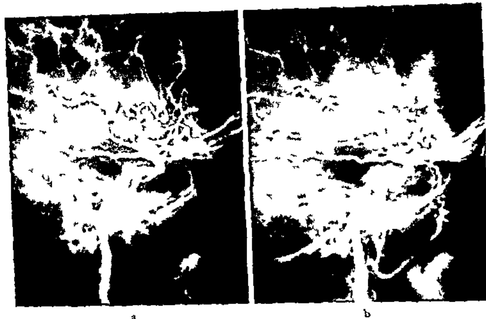


Fig. 1. a) Selective internal carotid angiography. No carotid cavernous fistula. b) Catheter has been repositioned and a more forceful injection resulted in reflux into the external carotid artery with demonstration of a fistula

forceful injection the external carotid artery was filled by reflux a fistula between the external carotid artery and cavernous sinus was demonstrated (Fig. 1b). The fistula and its venous drainage anteriorly was seen to better advantage in an a.p. projection (Fig. 2). Contrast medium injection into the contralateral carotid artery filled no fistula. When the contralateral internal jugular vein was catheterized the fistula on the original side was contrast filled even more clearly demonstrating its drainage into the superior ophthalmic vein and superior petrosal sinus (Fig. 3). Precise indication of the external carotid supply via its internal maxillary branches was obtained by subtraction (Fig. 4).

Discussion

In 1963 HAYES concluded that direct fistulous communication between branches of the external carotid artery and the cavernous sinus may develop after trauma. Yet in no case was there shown a major contribution from the external carotid artery prior to the trapping operation.

CASTAIGNE et coll. (1966) appear to be first to have described the spontaneous external carotid cavernous sinus communication. Their investigation demonstrated bilateral fistulae on selective examination of the external carotid arteries. Su

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EXTERNAL CAROTID CAVERNOUS FISTULAE

by

ARTHUR F ROSENBAUM and MANNIE M SCHECHTER

The most common intracranial fistula is the communication between the carotid artery and the cavernous sinus (DANDY 1935) Since the internal carotid artery courses through the cavernous sinus, the fistula can result from disruption of the artery (HAMBY 1952)

Fistulae occurring spontaneously between the external carotid artery and the cavernous sinus have been recognized but rarely (CASTAIGNE et coll 1966, MINGRINO & MORO 1967) We have observed an additional case by pre operative selective angiography

Case report

A 62 year old woman with a 2 month history of pain behind the right eye and a rushing noise in the head was admitted to the hospital of the Albert Einstein College of Medicine One month prior to admission she had had an injection into the right orbit but unfortunately the circumstances surrounding this are vague It may be presumed however that at that time she had developed symptoms indicative of her problem

On physical examination the right eye was suffused proptosed and pulsated slightly There was also weakness of the right extraocular muscles No other significant signs were observed

Selective internal carotid arteriography was unremarkable (Fig 1a) Since the external carotid branch had not been contrast filled the catheter was repositioned and with a more



Fig 4 Fistula and its afferent supply via branches of the external carotid artery appear more clearly in the subtracted image

carotid cavernous fistula the pulsating exophthalmos and chemosis decreased somewhat although angiography showed that the fistula was patent and unchanged In the case recorded by CASTAIGNE et coll of bilateral external carotid cavernous sinus fistulae ligation of one external carotid artery reduced the bruit but the ipsilateral eye signs remained although no fistula on that side could be shown angiographically MINGRINO & MORO claimed successful treatment (i e presumed closure of the fistula) following carotid ligation but no post-operative angiography was reported

The multiplicity of the therapies tried attests that no surgical method can be consistently relied upon to bring about a cure (DANDY 1935 ECHOLS & JACKSON 1959 HAYES 1963) The unsuccessful treatment of carotid cavernous fistulae have been ascribed to the presence of anastomotic channels maintaining the communication (HAMBY 1952 DANDY 1935) Our case has shown that it appears necessary to perform selective internal and external carotid angiography pre operatively to establish the precise site and supply of the fistula, in that this information cannot be obtained from common carotid angiography alone

SUMMARY

A spontaneous external carotid cavernous sinus fistula was demonstrated and the value of pre-operative elective angiography is stressed It should be possible by selective angiographic examinations to reduce the occurrence of failures in the treatment of carotid cavernous fistulae

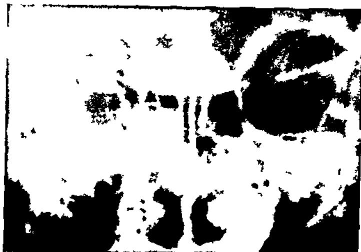


Fig 2 The fistula and its forward drainage through the superior ophthalmic vein is seen to better advantage in the a p projection



Fig 3 Contralateral internal jugular vein catheterization resulted in contrast filling of the fistula on the original side The superior ophthalmic vein and superior petrosal sinus drainage are better shown

sequently, MINGRINO & MORO (1967) described the second case, that of a unilateral external carotid cavernous sinus fistula

The morphologic fate of an external carotid cavernous fistula cannot be assessed clinically In our case, after internal carotid trapping of an external

SERVICE CENTRAL DE RADIOLOGIE DE LA SECURITE SOCIALE (SECTION DE NEURO RADIOLOGIE) ET SERVICE DE NEUROCHIRURGIE DE L HOPITAL CLINIQUE FACULTE DE MEDECINE BARCELONE ESPAGNE

ANGIOGRAPHIE DANS LES LESIONS ATHEROMATEUSES NON OBSTRUCTIVES DES ARTÈRES CEREBRALES

par

M Rovira

Les syndromes cliniques d insuffisance vasculaire cerebrale ne sont pas toujours accompagnes d images angiographiques demontrant de lesion arterielle Il est assez frequent de rencontrer des signes d arteriosclerose diffuse ou bien des images d atheromatose localisees au niveau du siphon carotidien ou dans les premiers segments (A_1—B_1) de la bifurcation de la carotide

Il est bien moins frequent dans l angiographie d observer l atheromatose localisee dans des arteres cerebrales plus distales Nous avons etudie 13 cas dans lesquels les lesions atheromateuses affectaient des arteres eloignees de la bifurcation carotidienne Dans ces cas les lesions arterielles ont une topographie variable et peuvent etre (1) localisees dans un seul vaisseau comme lesions uniques (Fig 1) (2) localisees dans un seul systeme arteriel (cerebral anterieur pericalleuse moyen ou posterieur) (Fig 2) ou (3) diffuses affectant toutes les arteres cerebrales (Fig 3) ou (4) accompagnant une lesion thrombotique

Au point de vue dynamique nous avons observe qu une stenose isolee produite par une plaque d atherome n occasionne pas une ischemie importante dans le territoire distal de la lesion Ces stenoses peuvent etre accompagnees d une dilata

ZUSAMMENFASSUNG

Eine spontane Fistel der A. carotis externa im Sinus cavernosus wurde nachgewiesen und der Wert pre-operativer selektiver Angiographie wird hervorgehoben. Selektive angiographische Untersuchungen dürften Misserfolge bei der Behandlung von solchen Fisteln reduzieren.

RÉSUMÉ

Les auteurs ont mis en évidence une fistule spontanée entre la carotide externe et le sinus caverneux; ils soulignent l'intérêt de l'angiographie sélective pré-opératoire. Il devrait être possible grâce aux examens angiographiques sélectifs de réduire la fréquence des échecs du traitement des fistules carotido-caverneuses.

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Au point de vue dynamique nous avons observe qu une stenose isolee produite par une plaque d atherome n occasionne pas une ischemie importante dans le territoire distal de la lesion Ces stenoses peuvent etre accompagnees d une dilata



Fig 1 Angiographie de la carotide gauche Stenose produite par la plaque d atherome dans la partie inferieure de l artère cerebrale pericalleuse (←—)



Fig 2 Angiographie de la carotide droite Il existe de multiples stenoses produites par des plaques d atherome dans les arteres pericalleuse (←—) calloso marginale et cerebrale posterieure (←→)

tion anoxique de la zone de l artere immediate, dilatation qui permet la plupart des fois une repletion normale du reste de l'arbre arteriel (Figs 2 et 4)

Ce n est que dans les cas ou il existe (1) une lesion vasculaire diffuse, d autre etiologie, (2) une serie de plaques d atherome dans un même vaisseau, lesquelles produisent des stenoses successives, ou (3) une descente de la pression arterielle systemique, que ces stenoses peuvent occasionner des lesions par ischemie cerebrale

C est pour cela que l on peut observer fortuitement certaines de ces lesions en pratiquant des etudes angiographiques pour des raisons differentes

La symptomatologie clinique, lorsqu elle se presente, est tres variee et depend du foyer d ischemie occasionne par la stenose atheromateuse de l artere Comme c est le cas dans la plupart des processus vasculaires cerebraux un probleme se pose frequemment celui du diagnostic differentiel avec des lesions expansives Lorsque l on parvient a obtenir la visualisation des plaques d atherome dans l angiographie et que celles ci coincident en même temps avec la focalite des symptômes, l interpretation diagnostique s en trouve enormement facilitee

Il faut faire ressortir que chez deux de nos malades le tableau initial fut d hemorragie sous arachnoidienne sans que l etude angiographique ait pu demontrer l existence d anevrismes Dans les deux cas, il s agissait de lesions atheromateuses



Fig 3 Angiographi de la carotide gauche Grande irregularite de toutes les artères cer brales du fait de la presence de nombreuses plaques d atherome



Fig 4 Ang ographie de la carotide gauche Il existe de nombreuses plaques d a the ome di trib u es dans tout le systèm arteriel cerebral (←) Dans une bran he de la cer b ale moyenne on peut observer une serie de stenoses (↔) su es d une dilatation pl is distale de cette artère



Fig. 5. Angiographie de la carotide gauche. Il existe de nombreuses plaques d'athérome distribuées dans tout le système artériel cérébral (⟵). Dans une branche de la cérébrale moyenne on peut observer une série de sténoses (⟵) suivies d'une dilatation plus distale de cette artère.



Fig. 6. Angiographie de la carotide gauche, projection antéropostérieure. Une thrombose de l'artère cérébrale moyenne est présente au niveau de la bifurcation de la carotide interne. Il existe une plaque d'athérome qui produit la sténose de l'artère cérébrale antérieure (⟵).

très typiques et on ne pouvait en aucune façon les confondre avec des spasmes artériels (Figs 2 et 5).

L'existence simultanée de plaques d'athérome et d'une obstruction de quelque artère cérébrale, indique déjà une diffusion du processus artériopathique et, de ce fait, plus de gravité dans le pronostic. La circulation vicariante se trouvera affectée en rapport direct au nombre de lésions athéromateuses que présentent les artères perméables, en effet, s'il n'existe qu'une seule sténose et en admettant même qu'elle ait une certaine intensité, elle ne peut empêcher notablement la formation d'une circulation suppléante (Fig. 6).

Finalement, dans tous ces cas, et en laissant de côté ceux qui présentaient en outre des lésions thrombotiques, l'étude électroencéphalographique a démontré l'existence de lésions localisées dans d'amples zones d'un hémisphère cérébral avec peu de tendance à la diffusion, lesquelles ne coïncidaient pas toujours avec la lésion anatomique, à moins que celle-ci ne fût d'une étendue et intensité importantes.

RÉSUMÉ

L atheromatose des arteres cerebrales est difficile a deceler par angiographie lorsqu elle n a pas encore occasionne une occlusion permanente du vaisseau La revision de notre matériel angiographique nous a permis de selectionner une serie d images de lesions athéromateuses des arteres cérebrales localisees dans un petit fragment de vaisseau ou bien plus diffu es et généralisees

SUMMARY

It may be difficult angiographically to demonstrate atheromatous lesions of the cerebral arteries unless permanent occlusion of the vessel has occurred Reviewing our angiographic material we were able to select a eries of roentgenograms showing atheromatous lesions of the cerebral vessels localized either to a small portion of the vessel or diffusely and widely distributed

ZUSAMMENFASSUNG

Es mag schwierig sein, atheromatose Lasionen der cerebralen Arterien angiographisch nachzuweisen bevor es zu einem permanenten Verschluss des Gefasses gekommen ist. Bei einem Durchgang unseres angiographischen Materials konnte eine Serie von Rontgenbildern aus ewahlt werden, die atheromatose Veranderungen der Hirngefasse zeigten die entweder in einem kleinen Teil des Gefasses lokalisiert waren oder diffus und weit verteilt waren

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FATE OF EXPERIMENTAL AUTOLOGOUS EMBOLI

by

C I RUMBAUGH, D O DAVIS and J M GILSON

An experimental model in which autologous emboli could be introduced into the intracranial vessels in the dog was developed in an effort better to understand *cerebral embolism in man* *Attention was in particular directed toward improving* the diagnosis of cerebral embolization by means of angiography and toward a better understanding of the accompanying pathophysiologic changes Also, before various forms of embolization therapy could be evaluated, it seemed appropriate to study the natural history of an embolus and its sequelae with no treatment

Material and Methods A standardized technique was used for catheterization of the internal carotid artery and preparation of the embolus from a sample of the dog s venous blood and for introduction of the embolus (DAVIS et coll 1967 RUMBAUGH et coll 1968) Axial and lateral angiograms were obtained immediately *before embolization, immediately after embolization* and then every thirty minutes for four hours, and finally at twenty four hours in the surviving animals

Results

Of the 18 dogs used in the study nine died as a result of the *embolization* All deaths occurred within 24 hours The remaining animals survived the embolization but *were* sacrificed within 30 days

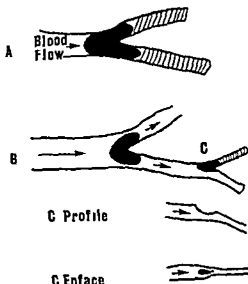


Fig 1 Schematic illustration of various configurations of emboli

Almost all emboli lodged at a vessel bifurcation or branching When the main vascular channel was completely blocked (Fig 1 A) the characteristic appearance of an embolus as usually described in the literature was seen If some contrast material passed by the embolus the embolus in its entirety was faintly outlined and it could be recognized as lodging in a vessel bifurcation (Fig 1 B) The embolus was often situated primarily in one of the branches however possibly completely blocking it and slightly protruding into the lumen of the main channel or some other branch (Fig 1 C)

It may at first not be recognized that one branch is completely blocked but there are certain clues First the lumen of the other branch which may also be partially blocked may suddenly appear reduced in size compared to the larger main channel just proximal to it this indicates presence of a bifurcation one branch of which has not been outlined Secondly the diameter of the lumen of the parent artery may also be decreased by embolic material at the origin of the occluded branch The embolus if seen in profile may have a smooth convex out line producing a hump along the vessel if seen en face it may be recognized as a short segment of vessel with decreased contrast filling and rapidly diminishing caliber (Fig 1 C) This appearance could easily be mistaken for spasm or an arteriosclerotic plaque if one did not have a pre-embolization angiogram Parenthetically in none of our acute studies did we identify spasm This latter observation parallels that of RUSSELL (1966) In fact there usually was some dilatation



a



b



c

Fig 2 a) Axial projection of the arterial phase of a cerebral angiogram of a dog showing normal course and patency of the right middle cerebral artery (arrow) The bifurcation is just beyond the arrow b) Repeat angiogram showing occlusion of a middle cerebral artery branch distal to the bifurcation The arrow indicates a portion of the embolus lodged in the main middle cerebral trunk c) Angiogram obtained subsequent to the one shown in (b) The middle cerebral branch has re opened (above the arrow) The embolus has migrated distally in the main trunk to the point shown by the arrow

of the vessel proximal to the embolus for the first 3 or 4 hours A third clue may be that since the contrast medium outlines only one trunk of a bifurcation, or one branch there may be an abrupt angulation of the contrast column at the site of the embolus

With passage of time, some of the emboli could be seen to fragment and small

fragments migrated into more distal branches In some cases there appeared to be dissolution of the embolus with a gradual loss of embolus mass although no definite smaller fragments could be identified

Some of the findings now discussed are illustrated in the following example In the preliminary axial angiographic film (Fig 2a) the middle cerebral artery of the dog is normally outlined Embolization through an internal carotid catheter was performed In a subsequent film (Fig 2b) occlusion of a small branch of the middle cerebral artery is seen part of the embolus is visible en face in the main trunk of the artery A later film (Fig 2c) shows clearing of this portion of the artery and migration of the embolus now seen more distally in the main trunk The previously blocked branch is again contrast filled No narrowing or spasm are evident

Findings such as these were consistently seen with this technique

Acknowledgements

The study was undertaken when C L. Rumbaugh was a NINDB Special Fellow No F11 NB 1399 and J M Gilson NINDB Special Fellow No F11 NB 1733 0? The work was in part supported by USPHS Grant No 1 PO 1 NB 06833-01 NBP

SUMMARY

The fate of experimental autologous cerebral emboli in the dog was demonstrated by angiography Following the initial block of the vessel a fairly rapid distal migration of embolic material took place In all cases in which a 24 hour post embolic angiogram was obtained the embolus was significantly smaller or no longer visible Infarction was found at all the post mortem examinations Some angiographic configurations of small vascular emboli and their change with time are demonstrated

ZUSAMMENFASSUNG

Der Verlauf bei Untersuchung von experimentell autologen cerebralen Emboli im Hunde wurde angiographisch demonstriert. Auf die erste Blockierung des Gefasses erfolgte eine ziemlich schnelle distale Migration des embolischen Materials In allen Fällen in denen ein Angiogram des Embolus nach 24 Stunden dargestellt wurde war der Embolus bedeutend kleiner oder nicht mehr sichtbar Infarzierung wurde bei allen post mortem Untersuchungen gefunden Einige angiographische Konfigurationen von kleinen Gefassemboli und deren zeitlichen Veranderungen werden illustriert

RÉSUMÉ

Ce travail de recherche montre par des angiographies le devenir des embols cerebrals autologues expérimentals sur le chien Apres l obstruction initiale du vaisseau l embol migre assez rapidement vers la region distale Dans tous les cas ou on a fait une angiographie 2x



a



b



c

Fig 2 a) Axial projection of the arterial phase of a cerebral angiogram of a dog showing normal course and patency of the right middle cerebral artery (arrow) The bifurcation is just beyond the arrow b) Repeat angiogram showing occlusion of a middle cerebral artery branch distal to the bifurcation The arrow indicates a portion of the embolus lodged in the main middle cerebral trunk c) Angiogram obtained subsequent to the one shown in (b) The middle cerebral branch has re opened (above the arrow) The embolus has migrated distally in the main trunk to the point shown by the arrow

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ETUDE ARTERIOGRAPHIQUE DES MENINGIOMES SUS TENTORIELS

par

G SALAMON A COMBALBERT G GIUDICELLI W PELLET et F VITTINI

La confrontation de donnees radio-anatomiques concernant la vascularisation normale de la dure mere et de dossiers de soixante meningiomes etudies par angiographie selective de la carotide interne et de la carotide externe constitue l objet de ce travail

Il apparait que tout meningiome quelque soit son siege, presente en general une vascularisation liee tres etroitement a celle de la dure mere qui l irrigue normalement Cela etait d ailleurs pressenti par LIMA (1950) qui a donne des meningiomes et de leur vascularisation un schema que nous avons pratiquement toujours retrouve

Nous diviserons ce travail en trois parties meningiomes de la convexite de la faux et de la base (Nous eliminerons de cette etude les modifications vasculaires cerebrales lorsqu elles ne concernent pas l irrigation du pedicule de la tumeur refoulement compression veineuse troubles de la dynamique circulatoire

I *Les meningiomes de la convexite*

Ils ont ete etudie depuis fort longtemps et sont parmi les diverses varietes topographiques les mieux connus

heures apres lembolie lembol n etait plus visible ou etait nettement plus petit Dans tous les cas lexamen post mortem a montre un infarctus cerebral Ce travail a mis en evidence les aspects angiographiques d embolies de petits vaisseaux et leur modification dans le temps

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a b

Fig 2 a) Pièce anatomique Dure mere isolee de la region frontale b) Meningiome du pole frontal (arteriographie carotidienne externe) Trois sortes de pedicules meninges vont participer à l irrigation du meningiome une branche de la meningee moyenne suit le bord d insertion de la faux une branche meningee aborde directement la tumeur enfin un volumineux pedicule provenant de l artere temporale superficielle traverse l os a ce niveau



a b

Fig 3 a) Pièce anatomique montrant la naissance de l artère meningee moyenne de l artere ophtalmique Seule passe par le trou petit rond une artere qui represente la branche la plus posterieure de l artere meningee moyenne b) Exemple de meningiome de la voute dont le pedicule meningee est represente par l artere méningee moyenne naissant de l artère ophtalmique très hypertrophiee

dure mere Les branches de l artere temporale superficielle ne participent pas a l irrigation osseuse de la voute Souvent dans certains meningiomes de la convexite des branches de l artere temporale superficielle viennent egalement participer avec celles de la dure mere à l irrigation tumorale (Fig 2b)

Il peut arriver que l artere meningee moyenne tire son origine du moins pour sa

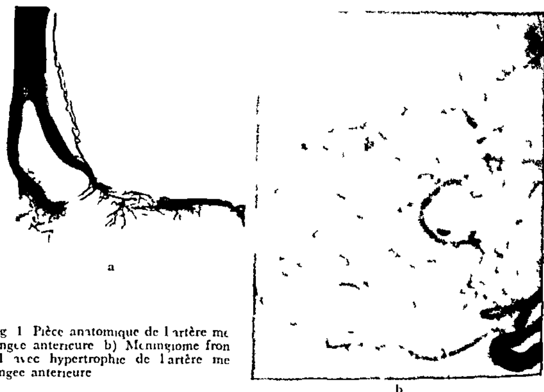


Fig. 1. Pièce anatomique de l'artère méningée antérieure. b) Méningiome frontal avec hypertrophie de l'artère méningée antérieure.

LIMA (1950), le premier, puis LORENZ (1940), LINDGREN (1954, 1957), WICKBOM et coll. (1958), puis plus récemment JACOBSON (1959), KRAYENBUHL & YASARGIL (1965), BERTAZZOLI (1965), RUGGIERO & DETTORI (1967), SCHUNK, DAVIS & DRAKE (1964), DILENGE et coll. (1964) ont apporté une contribution à leur étude artériographique.

La dure mère de la convexité est irriguée pour sa majeure partie par l'artère méningée moyenne et ses branches de division.

Les méningiomes de la convexité présentent le plus souvent un ou plusieurs pédicules artériels tirant leur origine d'une de ces branches de l'artère méningée moyenne.

Trois caractères sont en faveur d'un méningiome : (1) l'hypertrophie de l'artère méningée moyenne ; (2) l'existence de néo-vaisseaux au temps précoce et (3) plus tardivement celle d'un blush. Les néo-vaisseaux forment un pédicule en bouquet qui *aborde la néoformation sur son pôle d'insertion*. De telles images caractérisent la majeure partie des méningiomes de la convexité.

Dans la région frontale, l'artère méningée antérieure peut participer à la vascularisation tumorale (Fig. 1).

Branche de l'ophtalmique, l'artère méningée antérieure suit de chaque côté la ligne médiane le long du bord d'insertion de la faux.

A l'état normal, le diploé est vascularisé exclusivement par les artères de la

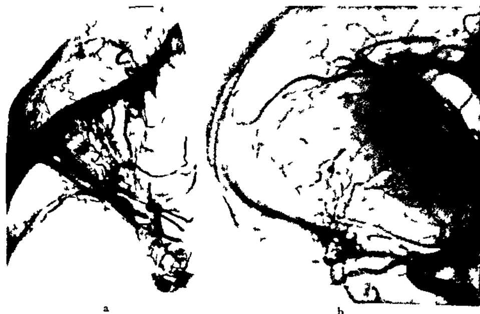


Fig 5 a) Pièce anatomique Vue axiale de l'orbite et de la gouttière olfactive montrant la naissance de l'artère ethmoïdale postérieure à partir de l'artère ophtalmique b) Méningiome de la gouttière olfactive irrigué par un pédicule dural issu de l'artère ethmoïdale postérieure

II Les méningiomes de la faux (Fig 4b et 4c)

Leur étude artériographique a été envisagée par ROUKKULA & SALTZMAN (1963) BERNASCONI & CASSINARI (1966)

La faux présente une vascularisation complexe Son bord d'insertion adhérent est vascularisé à sa partie moyenne par des ramifications de l'artère méningée moyenne a sa partie antérieure par l'artère ethmoïdale antérieure a sa partie postérieure par une branche de l'artère vertébrale l'artère méningée postérieure lorsque cette branche est développée Son bord libre est vascularisé par une branche de l'artère calloso-marginale

Cela explique qu'un méningiome de la faux puisse être vascularisé soit par la carotide interne seule s'il est situé près de son bord libre soit à la fois par la carotide interne et la carotide externe s'il est situé près de son bord adhérent ou plus étendu

III Les méningiomes de la base

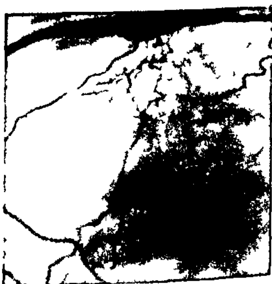
Leur vascularisation plus complexe a été abordée (Fig 4) par LOMBARDI & CECCHINI 1960) pour la région orbitaire SCHNERER & STATTIN (1963) pour la



a



b



c

Fig. 4. a) Pièce anatomique montrant la vascularisation de la partie antérieure de la faux dépendant de la méningée moyenne et de branches de l'artère péricalleuse. b) et c) Ce méningiome de la faux présente un pédicule dural d'origine carotidien interne, méningée moyenne et temporale superficielle.

majeure partie de l'artère ophtalmique. Le méningiome pariéto-occipital de la Fig. 3b a ainsi un pédicule de ce type. Dans ce cas, la seule artériographie sélective de la carotide interne permet de préciser l'étiologie du processus expansif.

Cependant sur cette série, un seul cas de méningiome sur 60 ne présentait après l'artériographie carotidienne interne et externe aucune image évoquant l'existence d'un pédicule anormal.

On peut donc penser que le schéma de la vascularisation des méningiomes se superpose assez exactement à celui de la vascularisation méningée normale.

Pour une localisation donnée devant un processus expansif intra-crânien l'hypertrophie d'une branche méningée, ou ce qui est identique, la visualisation d'un vaisseau méningé qui n'est normalement pas visible, l'existence de néo-vaisseaux, l'opacification tardive sous forme d'une tache homogène permettent sinon toujours du moins dans la grande majorité des cas d'affirmer l'existence d'un méningiome.

Le schéma du pédicule anormal est pratiquement toujours identique à celui décrit par LIMA. Les autres modifications circulatoires sont contingentes.

À l'inverse, suivant le type de la vascularisation pathologique, on peut préjuger avec assez de précision du siège exact du méningiome et des problèmes opératoires que pourra poser la ligature de ses pédicules.

Il apparaît que l'étude artériographique des méningiomes ne se conçoit clairement que si elle prend pour base le schéma de la vascularisation normale de la dure-mère.

RÉSUMÉ

Les auteurs présentent les résultats de l'étude angiographique de 60 méningiomes. Les cas étudiés ont tous eu une exploration sélective de la carotide interne et de la carotide externe par angiographie en série rapide et soustraction. Ils montrent que le pédicule artériel du méningiome correspond pratiquement toujours à un ou plusieurs vaisseaux qui irriguent normalement la dure-mère à ce niveau.

SUMMARY

The angiographic findings in 60 cases of meningioma are presented. Selective exploration of the internal and external carotid arteries was performed in all the cases by means of serial angiography using the subtraction method. It was found that almost always the arterial pedicle of the meningioma consisted of one or more vessels that normally feed the dura mater at this level.

ZUSAMMENFASSUNG

Die angiographischen Befunde bei Untersuchung von 60 Fällen mit Meningiom werden vorgelegt. Die selektive Untersuchung erfolgte in sämtlichen Fällen mittels Serienangiographie der A. carotis interna und externa und Subtraktion. Es zeigte sich, dass der Arterienschaft des Meningioms fast immer aus einem oder mehreren der Gefässe bestand, die normaler die Dura mater in dieser Gegend versorgen.

région du sinus caverneux, CASSINARI & BERNASCONI (1958), DILENGE et coll. (1964), BRIANI & GALLIGIONI (1959).

Au niveau de la base, nous étudierons les méningiomes de l'étage antérieur (gouttière olfactive et toit de l'orbite) et ceux de l'étage moyen (jugum et petite aile).

1. *La vascularisation de la lame criblée* par l'artère ethmoïdale postérieure explique que les méningiomes ethmoïdaux soient pratiquement toujours vascularisés par cette branche (Fig. 5).

2. *Au niveau du toit de l'orbite*, malgré la pauvreté d'irrigation méningée à ce niveau, l'existence d'un méningiome se traduit encore par l'hypertrophie des artères de la dure mère et l'existence de néo-vaisseaux.

3. *Les méningiomes du jugum* nous ont paru avoir sur les bases de l'artériographie sélective carotidienne interne ou externe une vascularisation pathologique souvent très pauvre et parfois même totalement inapparente sur les séries angiographiques. Peut-être faut-il voir là le reflet d'une irrigation vasculaire peu riche au niveau de la dure mère de cette région à l'état normal.

4. *Les méningiomes de la petite aile.* La vascularisation de la dure mère de la petite aile est assurée dans son tiers interne presque exclusivement par des branches intra-caverneuses de la carotide interne et dans son tiers externe par de fines branches naissant du point où la méningée moyenne se réfléchit en regard du ptérion.

L'existence d'anastomoses entre l'artère méningée moyenne et l'artère ophtalmique confère à cette dernière une certaine part dans la vascularisation de la dure mère à ce niveau. Cette disposition explique sans doute que les méningiomes les plus externes (ptérion, partie externe de la petite aile) soient plutôt vascularisés par l'artère méningée moyenne.

Les altérations sont toujours identiques : hypertrophie de la branche artérielle nourricière, néo-vaisseaux et plus tardivement image d'opacification homogène.

Les méningiomes de la partie interne de la petite aile sont plutôt irrigués par les artères méningées issues de la portion intra-caverneuse de la carotide. Souvent cette irrigation est mixte : branches carotidiennes internes et branches de la méningée moyenne.

Conclusion

Le nombre assez restreint de méningiomes étudiés par soustractions d'artériographies sélectives de la carotide interne et externe pour chaque variété topographique ne nous autorise pas à donner de chiffres de pourcentage qui aient une véritable valeur statistique.

LA SERVICE DE NEURORADIOLOGIE, HOPITAL MAISONNEUVE, MONTREAL, CANADA

LA MIGRAINE COMPLIQUEE — ARTERIOPATHIE CEREBRALE ASSOCIEE

par

ANDRE SANSREGRET et MARC ST HILAIRE

Nous presentons trois cas de migraine compliquee dont un avant un caractere familial tres net En fait notre attention a ete attiree sur ce probleme a la suite de l etude du premier cas qui presentait des signes radiologiques tres inhabituels Nous nous sommes alors reportes a la litterature sur ce sujet et nous nous sommes attaches en particulier a l article de PEARCE & FOSTER (1965) traitant de l investigation de la migraine compliquee

Presentation de cas

Cas I Il s agit d une jeune femme de 23 ans presentant des episodes migraineux depuis l enfance et qui se presentait a l hopital avec un syndrome thalamique gauche et des phenomenes de Raynaud

Les cephalees occipitales d une duree de deux jours étaient frequemment associees avec une hemi par sthésie alternante et une astéreognosie À l examen elle présentait une ataxie gauche une hyperesthesie gauche et une main et une épaule gauches douloureuses

Il existait un souffle grade III dans la région de la carotide gauche et un souffle grade II dans la region de la sous-claviere droite Il y avait diminution du pouls radial gauche À l ophtalmodynamométrie il existait une tension diminuee de la moitie au niveau de l œil gauche Il existait enfin des signes d irritation corticale dans le region temporale droite a l electro Tous les tests de laboratoire en vue de la recherche d un maladie du collagene se sont avérés negatif

Premierement sur l arteriographie carotidienne gauche il existait une reduction per sistante et marquée du calibre de la carotide interne (Fig 1a) avec une circulation collaterale Fig 1b L artériographie carotidienne droite etait normale lors d un premier examen

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a b c

Fig ? a) et b) Aortographie oblique gauche a) Diminution de calibre de la sous-claviere droite obstruction de la carotide interne droite et stenose de la carotide interne gauche b) Stenose pers stante de la carotide interne gauche (Diagnost c arteriopathie carotidienne gauche) c) Arteriographie humerale Diminution de cal b e sur le trajet de l humerale gauche (D agnostic Arteriopathie carotid enne gauche et humerale)

egalement de cephalees Sa mere et son frere presentent des episodes migraineux Mal heureusement il fut impossible de les étudier d une façon plus poussee

Cas ? Il s agit d un patient de 31 ans presentant une migraine non familiale compliquee de dysarthrie A l électroencephalogramme il existait des signes d irritation corticale de la région temporale gauche A ce moment l artériographie carotidienne droite nous permettait de mettre en evidence des irr gularités parietales n ttement caractérisees le long de l artère an ulaire droite (Fig 3a) Un mois plus tard ce patient présentait une thrombose complete de la cerebrale moyenne droite et une hémiplegie gauche Il etait po sible a ce moment de vi ualiser ur le cliche d importantes irregularites au niveau de plusieurs vaisseaux de la carotid externe surtout au niveau de la maxillaire interne (Fig 3b)

Ce patient subit une biop ie de l artere faciale droite dont les resultats furent plus ou moins aléatoires mais ou il semblait quand meme exister un element de sclero e intimale t d fibro e p ri arteri lle Il faut cependant signaler qu une biopsie avait été pratique a e niveau malgre le peu de signe radiologique à cau e de l accessibilite de la faciale droite

Cas 3 Il s a it d une patiente de 35 ans suivie pour cephalees depuis 1961 plus ou moins bien controlée par le Cafergot et hospitalisee pour investigation Depuis janvier 1966 elle presentait des épisodes repetées d hémicranie gauche associée avec des douleurs au niveau

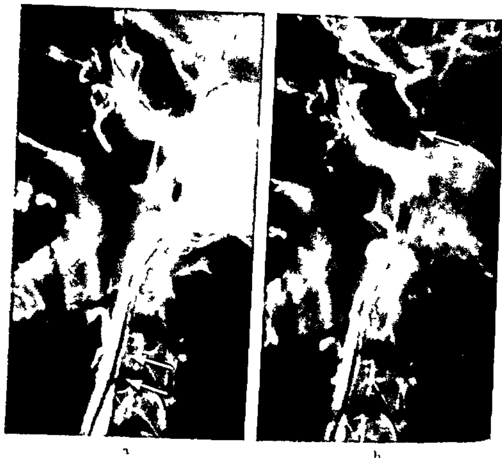


Fig 1 Cas 1 Artériographie carotidienne gauche de profil a) Réduction persistante et marquée du calibre de la carotide interne gauche b) Réduction de calibre de la carotide interne gauche avec circulation collatérale (Diagnostic artériopathie carotidienne gauche)

Deuxièmement une première étude de l arc aortique en oblique tourné vers la gauche démontrait une diminution de calibre de la sous clavière droite une obstruction de la carotide interne droite et toujours une sténose de la carotide gauche (Fig 2a) Une seconde étude de l arc aortique un mois plus tard démontrait la persistance d une empreinte au tronc innominé avec une perméabilité de la carotide droite et une sténose de la carotide gauche (Fig 2b) Enfin l artère humérale gauche présentait également une diminution de calibre ou la biopsie fut pratiquée (Fig 2c)

Le diagnostic histologique fut celui de fibrose de l intima la lésion en dedans de la limitante élastique externe pouvant se rapprocher d une hyperplasie fibro musculaire (M Lamoureux neuro pathologiste)

Il faut signaler que la sœur aînée de la malade était morte quelques mois auparavant à la suite d épisodes migraineux à répétition compliqués d hémiparésie droite de dysphasie et d épilepsie Malheureusement cette patiente n avait pas eu une étude radiologique adéquate dans notre milieu

À l autopsie on remarquait des foyers extensifs d infarctus dans la région des cérébrales moyennes Il faut enfin signaler que cette femme a une petite fille de 4 ans qui se plaint

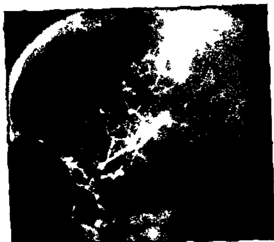


Fig 4 Cas 3 Artériographie carotidienne droite de profil Absence constante d opacification dans la temporale postérieure droite (Diagnostic artériopathie de la temporale postérieure droite)

Discussion

Les conclusions de l étude de 40 cas qui avaient subi 33 artériographies carotidiennes faites par PEARCE & FOSTER (1965) sont les suivantes une migraine associée avec des épisodes transitoires d hémiplégie d hémianopsie ou d ophtalmoplégie n est pas habituellement associée avec une lésion vasculaire

À la suite de nos trois cas nous croyons que ces conclusions sont fortement discutables et sujettes à révision En fait il se peut que nous soyons devant deux syndromes différents

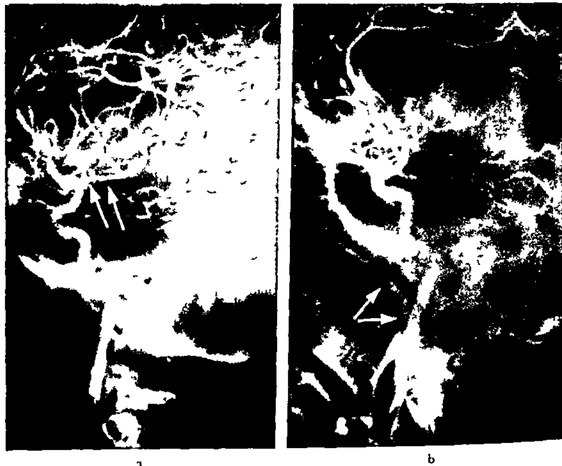
Un premier syndrome (du genre du premier cas présenté) serait caractérisé par (1) une migraine compliquée de longue date avec composante familiale (2) chez un jeune patient (3) associée à une artériopathie cérébrale (concomitante ou non avec une artériopathie périphérique ou rénale), (4) dont le diagnostic histologique se rapproche de l hyperplasie fibromusculaire de la *media*.

Un second syndrome (du genre de notre second et troisième cas) comprendrait (1) une migraine compliquée relativement récente (2) chez un patient autour de 30 ans, (3) associée à une artériopathie cérébrale (4) dont le diagnostic histologique n est pas encore très précis.

Au chapitre des diagnostics différentiels, il faut revoir les différentes causes d artériopathie

1 Il faut éliminer une artériopathie en relation avec une médication du genre Enovid cortisone Ergot ou encore une artériopathie en relation avec une hémoglobinopathie

2 Il faut également éliminer une artériopathie en relation avec une réaction méningée soit néoplasique (Hodgkin) ou inflammatoire Nous pouvons montrer



a b

Fig 3 Cas 2 Artériographie carotidienne droite de profil a) Irrégularité pariétale très nette le long de l'artère angulaire droite près de son origine (Diagnostic artériopathie de l'artère angulaire droite) b) Thrombose du groupe sylvien et irrégularité pariétale au niveau de la maxillaire interne en particulier (Diagnostic thrombose complète de la carotide interne droite artériopathie au niveau de la maxillaire interne)

de l'œil gauche une parésie du membre supérieur gauche des nausées et des vomissements Il y a une histoire de deux pertes de conscience Une sœur présente également des céphalées migraineuses L'examen neurologique était par ailleurs négatif

L'artériographie carotidienne gauche était négative mais on remarquait une absence constante d'opacification de l'artère temporale postérieure droite (Fig 4) Une première étude encéphalographique nous permettait de mettre en évidence une image d'empreinte au niveau de la paroi latérale gauche de la corne frontale (Fig 5)

Une étude des vaisseaux du cou pratiquée un mois plus tard nous permettait de mettre en évidence une modification de calibre de la carotide externe gauche et de l'origine de la vertébrale droite (Fig 6) Une nouvelle étude encéphalographique nous permettait d'identifier maintenant dans la région où existait la zone de compression antérieurement une zone d'atrophie nettement caractérisée et présentant tous les caractères d'une origine vasculaire (Fig 7)



Fig 7 Cas 3 Encéphalographie gazeuse Zone d atrophie nettement aracterisee dans la region ou existait l image d empreinte un mois auparavant (D agnostic arteriopathie cerebrale)



a



b

F g 8 a) Art riograph e arotid enne dro te a p Irregularite tres nette et diminution de calibre u r e u de l orig e de la ereb ale moyenne et de la cerebrale anterieure droite (D agnostic art op thie tuber uleuse prol able) b) Arteriograph e vertebrale de profil Retrecissement scul re et rregularites pa i tales nettes dans la region occipitale (Diagnostic malad e de St g W ber)

renales dans la neurofibromatose ce qui laisse presager qu il peut en exister probablement dans les autres phacomatoses

Enfin il faut signaler qu on a decrit recemment des arteriopathies cerebrales

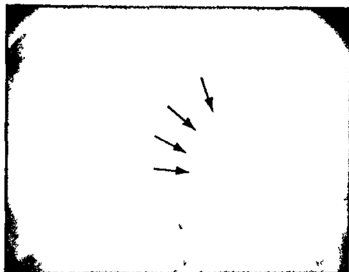


Fig. 5. Cas 3. Encéphalographie gazeuse. Image d'empreinte au niveau de la paroi latérale gauche de la corne frontale. (Diagnostic : artériopathie cérébrale.)



Fig. 6. Cas 3. Aortographie oblique gauche. Image d'empreinte au niveau de la vertébrale droite et irrégularité au niveau de la carotide externe gauche. (Diagnostic : artériopathie cérébrale.)

un cas d'un patient qui a présenté à notre hôpital une méningite selon toute vraisemblance d'origine tuberculeuse, et qui par la suite a subi une artériographie carotidienne plusieurs mois plus tard et qui a révélé des irrégularités évidentes au niveau de la bifurcation de la carotide interne, ce qui semblerait bien confirmer un processus artériopathique post-inflammatoire chez ce patient (Fig. 8a). Par ailleurs, DI CHIRO m'a déjà montré personnellement un cas de maladie de Hodgkin présentant également des irrégularités vasculaires.

3. Les artériopathies en relation avec les maladies du collagène (FACON et coll. 1960, SANDRING & WELIN 1961), pseudo-xanthome elasticus ou encore les artériopathies à cellules géantes (CROMPTON 1961), en fait, tout un groupe d'artériopathies plus ou moins associées. Il n'est pas impossible qu'on doive inclure sous ce chapitre la maladie de Takayasu (KOZUKA et coll. 1966, SHORT et coll. 1965).

4. Il faut enfin signaler les artériopathies en relation avec les phacomatoses du genre neurofibromatose ou Sturge-Weber. Il est possible de mettre en évidence des rétrécissements vasculaires et des irrégularités nettes dans une région occipitale (Fig. 8b). On sait par ailleurs que des lésions vasculaires se rapprochant de l'hyperplasie fibromusculaire ont récemment été décrites au niveau des artères

syndrome is characterized by a long lasting complicated migraine with a familial component in young patients and associated with cerebral arteriopathy akin to fibromuscular hyperplasia The other syndrome corresponds to a recent complicated migraine in young patients associated with cerebral arteriopathy but histologically of unknown nature

ZUSAMMENFASSUNG

In drei Fallen mit komplizierter Migrane wurden die pathologischen Verhaltnisse der Gehirngefasse angiographisch und histologisch untersucht Es mag zwischen zwei verschiedenen Syndrome unterschieden werden Das eine sollte durch eine langanhaltende komplizierte Migrane mit einer familiaren Komponente bei jungen Patienten die mit cerebraler Arteriopathie verbunden ist und fibromuskulare Hyperplasie ahnlich ist gekennzeichnet werden Das andere Syndrom sollte einer anhaltenden Migrane bei jungen Patienten mit cerebraler Arteriopathie entsprechen, die aber histologisch unbekannt ist

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concomittantes aux hyperplasies fibro-musculaires de la media chez les hyper tendus (PALUBINSKAS & NEWTON 1965) de sorte qu on peut se demander main tenant s il n'est pas indique d etudier les arteres cerebrales et la gerbe aortique chez tous les patients presentant une hypertension et une arteriopathie renale et vice versa s il n'est pas indique d'etudier les arteres renales chez nos patients migraineux presentant des signes radiologiques d arteriopathie

Conclusion

L'etude du diagnostic differentiel nous rapproche donc de nos conclusions a tirer a la suite de l etude radiologique de trois cas de migraine compliquee ou il fut possible de mettre en evidence des processus arteriopathiques radiologique ment decelables et etudies histologiquement dans deux cas

Nous voulons de nouveau signaler que les conclusions de PEARCE & FOSTER nous paraissent inexactes et qu au contraire, on doit rechercher chez tous les migraineux compliques une pathologie vasculaire

Dans cet optique, nous croyons qu il est insuffisant de se limiter a l arteriographie carotidenne bilaterale mais qu il faut en plus pratiquer une injection de la gerbe aortique chez tous ces patients On doit en particulier bien etudier la carotide externe

Les patients presentant une composante familiale devraient subir en plus une arteriographie peripherique et renale afin d eliminer une hyperplasie fibromusculaire de la media

Une biopsie arterielle devrait etre pratiquee chez tous les patients presentant une migraine compliquee

Il se peut que cette attitude puisse modifier dans l avenir l approche thera peutique

RÉSUMÉ

Dans trois cas de migraine compliquée une arteriopathie cérébrale a pu etre mise en evidence et étudiée histologiquement Un premier syndrome semble se dégager caracterise par un long passé migraineux compliqué familial chez un jeune patient associe a une arteriopathie cérébrale dont l histologie se rapproche de l hyperplasie fibromusculaire de la media Un second syndrome semblerait également exister ou la migraine compliqué che un jeune patient est récente et associee a une artériopathie cérébrale dont l histologie reste discutable

SUMMARY

Cerebro vascular pathologic conditions were studied angiographically and histologically in three cases of complicated migraine Two different syndromes are distinguishable One



Fig 1 Arrangement for intravenous angiotomography Positioning of patient's head places most intracranial vessels at right angle to direction of tube travel and demonstrates them most sharply while minimizing superimposition of petrous bones on vessels

The patient is positioned on the table with the long axis of his body perpendicular to the direction of tube travel (Fig 1) In this position, most of the intracranial vessels are also at right angles to the line of tube travel and are more sharply demonstrated A No 13 gauge needle is placed in the brachial vein of the extended right arm An arm to-retina circulation time is obtained after the injection of 10 ml of fluorescein by observation of the fluorescence of the retinal arteries with a Wood's lamp ophthalmoscope In patients without significant cardiopulmonary disease the circulation time is between 10 and 12 seconds Experience has shown that optimal contrast filling of cerebral vasculature occurs 2 to 3 seconds prior to the circulation time

Scout films are always obtained to check radiographic factors and depth of tomographic cut Finally a large bolus of contrast medium (90 % Hypaque a mixture of 30 % sodium diatrizoate and 60 % meglumine diatrizoate), usually 1 ml kg of body weight is injected rapidly into the vein and the tomographic exposure made at *the appropriate time Both the anteroposterior and the lateral* projections are made after separate injections of contrast medium

In the anteroposterior projection the plane of the uppermost coronal tomogram is at the level of the planum sphenoidale and the lowest plane is at the petrous pyramids (Fig 2a) This displays at various levels from top to bottom the sweep of the anterior cerebral arteries around the rostrum of the corpus callosum the pericallosal and callosomarginal arteries running in their sulci the

FROM THE SECTION OF ROENTGENOLOGY, MAYO CLINIC AND MAYO FOUNDATION
ROCHESTER, MINNESOTA, U S A

INTRAVENOUS CEREBRAL ANGIOTOMOGRAPHY

by

P F Sheedy and H L Baker Jr

Angiotomography is a less selective, less sophisticated neuroradiologic screening procedure which approaches in accuracy the more conventional contrast studies, yet has the low risk of such procedures as isotopic scanning, electroencephalography, and echoencephalography In the past, tomography has been used in conjunction with intra-arterial cerebral angiography (Fredzell & Greitz 1966 Rocca & Rosadini 1960a b, Rosadini & Rocca 1963) and intravenous injection of contrast material has been employed in studies of the cerebral vasculature (Pheline and associates 1956 Viallet and associates 1956) To our knowledge, the combination of intravenous injection of contrast media with tomography of the intracranial circulation has not been attempted

Technique Angiotomography consists of the intravenous injection of a large bolus of contrast medium followed by tomography of the head at a preselected time so that the intracranial arteries and veins are demonstrated

The only radiography equipment needed is a standard tomographic table and multileaf cassette, which can be attached to the Bucky tray We have modified a 10 cm multileaf cassette to hold 12 films and have used various intensifying screen combinations to obtain 12 simultaneous tomograms of approximately equal density



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Technique. Angiotomography consists of the intravenous injection of a large bolus of contrast medium followed by tomography of the head at a preselected time so that the intracranial arteries and veins are demonstrated.

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carotid siphons the middle cerebral arteries as they ramify in the sylvian fissure, and the basilar and posterior cerebral arteries The deep venous system including the internal cerebral veins in the midline and the thalamostriate veins laterally is also seen

Usually only one cerebral hemisphere is examined in the sagittal plane with the lateral projection (Fig 2b) Clinical localization of the suspected lesion or the findings on the anteroposterior projection determine the side to be examined In this projection the level of the cassette is adjusted so that the midline vessels are in focus on the uppermost plane Films of deeper planes will then show the middle cerebral artery ramification in the sylvian fissure and the films of the lowermost planes the vessels on the convexity of the brain (Fig 3) If the exposure is made slightly later the central venous system as well as the arteries will be depicted Prominently shown are the septal thalamostriate internal cerebral and basal veins as well as the dural sinuses

Results

Material We have examined 25 patients by the use of angiotomography and the results are encouraging as may be seen from the findings tabulated below

	Number of cases
No abnormality	8
Abnormality	13
Vessel displacement	6
Tumor vascularity	1
Vessel displacement and tumor vascularity	1
Ventricular dilatation	4
Thrombotic occlusion	1
Failure (technical difficulties)	4

Four early studies unfortunately failed because of technical difficulties Of the 21 successful procedures eight showed no abnormalities The results in six of these were sufficiently conclusive to obviate further investigation while in the seventh conventional angiography confirmed the angiotomographic results In the eighth case the possibility of a subdural hematoma was successfully excluded in a patient who had had a right internal carotid ligation for intracranial aneurysm and in whom right brachial angiography had failed to reveal the right middle cerebral artery

Thirteen examinations revealed significant abnormalities There were six instances of intracranial vessel displacement secondary to an expanding lesion two

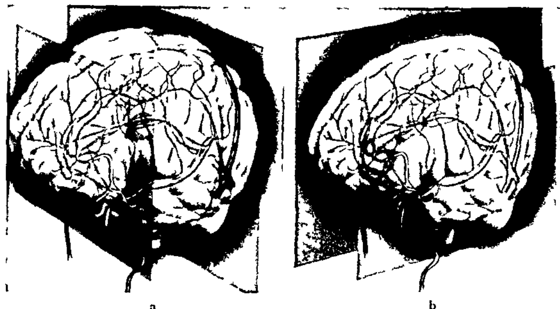


Fig 2 Planes of uppermost and lowest films in 12 film multileaf cassette a) Coronal planes of anteroposterior projection b) Sagittal planes of lateral projection

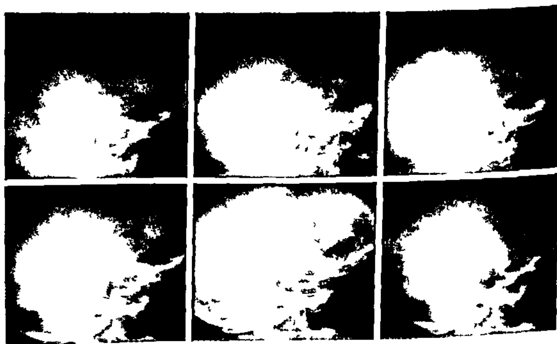


Fig 3 Six films from normal lateral angiotomography the first showing midline plane which depicts the pericallosal artery and its branches The intermediate planes reveal branches of the middle cerebral artery in the sylvian fissure and the lowest plane the level of the cerebral convexity



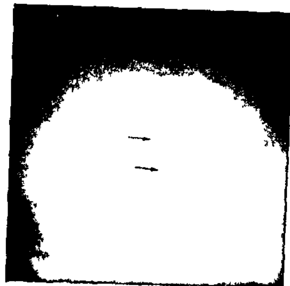
Fig 5 A p (a) and lateral (b) angiotomograms Arrows define the limits of the vascular mass in the right parieto-occipital region

Radiographic findings Displacement of the anterior cerebral arteries across the midline and depression of the right middle cerebral complex were seen in a patient with severe headaches but who had no localizing neurologic signs (Fig 4 a and b) These findings led to ventriculography which revealed a huge mass in the right frontal region that displaced the ventricular system to the left (Fig 4c) At operation a subdural hygroma was found

In another study displacement of the anterior cerebral arteries to the right was associated with elevation of the pericallosal and callosomarginal arteries and with depression and deformity of the internal cerebral veins posteriorly A subsequent encephalogram demonstrated a huge parieto-occipital parasagittal mass which depressed and displaced the left lateral ventricle A leptomeningeal cyst on the left which extended to the right beneath the falx and above the splenium of the corpus callosum was found at operation

Angiotomography can also provide useful information after surgery Displacement of the anterior cerebral arteries to the right together with depression of the right middle cerebral artery complex was seen in a patient who was not doing well two weeks after evacuation of a left parietal epidural hematoma These findings indicated the presence of a right frontoparietal mass as well as recurrence of the left epidural hematoma At re operation both lesions were verified the lesion on the right was a subdural hematoma.

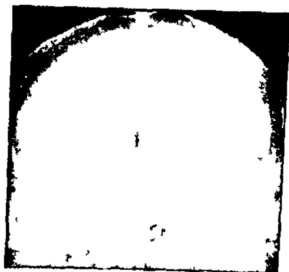
A large vascular mass in the right parieto-occipital region was discovered in



a



b



c

Fig. 1. Large right frontal subdural hygroma. a) and b) Angiotomograms demonstrating depression of the right middle cerebral artery complex and contralateral displacement of the pericallosal arteries. c) Ventriculogram which confirmed the angiotomographic diagnosis.

of tumor vascularity (one with and the other without vessel displacement), four of symmetric lateral ventricular dilatation, and one of thrombotic occlusion of the middle cerebral artery. In nine of the thirteen cases, the abnormal findings led to more definitive neuroradiologic examinations, which confirmed the angiotomographic impressions. In the remaining four cases, additional studies were not deemed necessary because angiotomography confirmed the presence of suspected metastases in two cases, suprasellar extension of a pituitary tumor in one case, and ventricular dilatation secondary to stroke in another.

Significant degrees of ventricular dilatation with depression of the internal cerebral veins elevation of the pericallosal and callosomarginal arteries and lateral displacement of thalamostriate veins can be detected with angiotomography as was seen in a patient with severe headache and papilledema (Fig 6a) Ventriculography revealed a mass in the region of the quadrigeminal plate the mass obstructed the posterior region of the third ventricle and the aqueduct of Sylvius (Fig 6b) A Torkildsen shunt was performed

The instance of occlusion of the right middle cerebral artery was seen in a patient with left hemiplegia (Fig 7) No further studies were required

Conclusion

We are aware of the inherent limitations of intravenous angiotomography and wish to stress its use as a screening procedure

There are many patients whose symptoms and signs are non specific or minimal and whose condition might not warrant further investigation with the highly selective procedures of modern neuroradiology These patients can be evaluated with angiotomography

The method is simple and requires a minimum of special equipment It is inexpensive because hospitalization and anesthesia are not necessary it can be accomplished rapidly with a minimum of personnel it entails less risk and fewer complications than do the more conventional contrast studies and it is more specific than electroencephalography echoencephalography and isotopic scanning As a screening examination intravenous angiotomography can reliably demonstrate the vascular changes associated with intracranial expanding lesions of all types vascular tumors ventricular dilatation major arterial occlusions and hopefully arteriovenous malformations and aneurysms

We know that this examination will not be a substitute for the more sophisticated neuroradiologic procedures but we believe that it will find a place in neuroradiologic diagnosis We intend to pursue the clinical applicability of angiotomography and hope to refine our techniques further so as to preserve its simplicity yet increase its reliability

SUMMARY

Intravenous angiotomography is a new neuroradiologic screening procedure used for initial evaluation in patients with suspected intracranial disease The procedure is similar to nephrotomography except that the brain is the organ of radiographic interest A large bolus of contrast medium is injected and at a predetermined time after injection tomographic roentgenograms are obtained with a view to demonstrate both arteries and veins Such abnormalities as displacement of vessels tumor vascularity and vascular occlusions may be detected The method is simple and inexpensive



Fig 6a



Fig 6b



Fig 7

Fig 6 a) Lateral angiotomogram Broad sweep of pericallosal artery and depression of internal cerebral vein indicate ventricular dilatation b) Ventriculogram confirming the ventricular dilatation (Other views revealed a tumor of the quadrigeminal plate)

Fig 7 Patient with suddenly occurring left hemiparesis Angiotomography demonstrates occlusion of the right middle cerebral artery just distal to its origin

a patient who had progressive mental deterioration and ataxia and in whom a cerebellar fibrosarcoma had been resected 2 years previously (Fig 5) Because of the newness of angiotomography at the time of this study, a right retrograde brachial angiogram was obtained to confirm the observation, and a vascular tumor corresponding in size and location to that seen in the original study was demonstrated A recurrent fibrosarcoma was found at surgery

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ZUSAMMENFASSUNG

Intravenose Angiotomographie ist ein neues neuroradiologisches Verfahren bei dem eine initiale Auswahl von Patienten mit einer vermuteten intrakraniellen Erkrankung geschieht Es kann mit Nephrotomographie verglichen werden mit der Ausnahme dass man das Gehirn untersucht Es wird ein grosser Bolus von Kontrastmittel injiziert und zu vorher bestimmten Zeitpunkten nach der Injektion werden tomographische Rontgenogramme angefertigt um die Arterien sowie die Venen darzustellen Abnormalitäten wie Verlagerungen von Gefässen die *Gefässversorgung von Tumoren und Gefässverschlüssen* lassen sich so darstellen Die Methode ist einfach und billig

RÉSUMÉ

L angiotomographie cerebrale par voie intraveineuse est une nouvelle methode neuroradiologique de depistage utilisee pour le bilan initial des malades soupçonnes d affection intracranienne Cette technique est semblable a la néphrotomographie On injecte par voie intraveineuse un gros embol de moyen de contraste et on fait des tomographies dans un temps pre determine apres l injection qui montrent les arteres et les veines Les auteurs ont *ainsi decele des deplacements des vaisseaux des vaisseaux tumoraux* et des obstructions vasculaires Cette methode est simple peu couteuse et comporte peu de danger

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CIRCULATION VERTEBRO BASILAIRE DANS LES MALFORMATIONS DE LA CHARNIÈRE CRANIO VERTEBRALE

par

F SMALTINO F P BERNINI et R ELEFANTE

Dans les malformations de la charniere cranio-vertebrale les troubles neurologiques sont attribues soit a la compression directe des formations osseuses qui ont un rapport tres strict avec les formations nerveuses adjacentes soit a l alteration des voies de la circulation du liquide cephalo-rachidien dans la fosse posterieure

En 1905 THOMAS et coll envisageaient dejà cliniquement l existence probable d un facteur vasculaire a l origine de ces troubles et cette hypothese a ete recemment confirmee par les etudes angiographiques morphologiques et dynamiques du systeme vertebro-basilaire en particulier chez les sujets avec impression basilaire Des anomalies du trajet de l artere vertebrale au niveau de la deformation osseuse ont ete constatees par DRIESEN (1961) DJINDJIAN & HURTH (1964) un retrecissement du calibre ou l agenesie d une des arteres vertebrales par DJINDJIAN & HURTH et LEGRE et coll (1967), un arret du flux sanguin vertebral le plus souvent au niveau du segment terminal pendant les mouvements forces de la tete par CIANI et coll (1964) KLAUSBERGER et coll (1965) et JANEWAY et coll (1966)



Fig. 1. Artériographie vertébrale droite pendant le mouvement de rotation de la tête vers la gauche. a) Le flux sanguin est interrompu à la jonction V2—V3. b) Injection de la première courbe de V3 dans une phase tardive. c) Artériographie vertébrale gauche pendant le mouvement de rotation de la tête vers la gauche. Pas de modification du flux sanguin.

Nous avons étudié 20 cas de malformations de la charnière cranio-vertébrale au cours des premiers 40 ans de la vie et sans lésions spondylosiques ou artério-scléreuses.

La technique employée a été la ponction percutanée de l'artère brachiale, selon la méthode de SIQUEIRA et coll. (1962) et le contraste a été aussi injecté dans les positions de flexion, d'extension et de rotation forcée de la tête d'un côté ou des deux côtés. Dans neuf cas l'examen a été bilatéral.

Dans le but de contrôle, la même technique a été utilisée dans une série de 15 jeunes malades, sans lésions de la charnière cranio-vertébrale.

Anomalies osseuses. Elles sont caractérisées principalement par une impression basilaire, isolée dans 4 cas, associée à l'occipitalisation complète ou incomplète de l'atlas dans 16 cas.

Anomalies morphologiques de l'artère vertébrale. Elles sont représentées par des modifications du trajet de l'artère, ou de son calibre et de sa terminaison.

Les anomalies du trajet, bien visibles dans 70 % des cas, sont caractérisées par une surélévation de la portion horizontale du segment V3 avec réduction de la boucle de sécurité et par un refoulement dorso-convexe de la partie initiale du segment V4. Elles sont d'autant plus nettes que la malformation est plus accusée (ce qui est en accord avec les affirmations de DJINDJIAN & HURTH 1964).



Fig 2 Arteriographie vertébrale gauche a) Position normale de la tete Le contraste passe assez bien dans le tronc basilaire b) Extension Le contraste passe beaucoup mieux dans le tronc basilaire c) Flexion Le contraste n injecte pas le tronc basilaire

Chez trois malades l artere vertebrale etait de calibre filiforme et se terminait une fois directement par l artere cerebelleuse postero-inferieure, tandis que dans les deux autres cas elle n est plus visible apres son entree dans le trou occipital

Anomalies de la dynamique circulatoire vertebro basilaire Elles etaient absentes dans 10 cas dans les 10 autres nous avons observe independamment du type de mouvement de la tete une diminution du flux sanguin demontree par une reduction du calibre de l artere ou un arret de ce flux

Chez sept de ces derniers malades on a constate l apparition de troubles neurologiques variables selon les mouvements de la tete (1) en rotation nystagmus horizontal dans deux cas algies cervicales cephalees vertiges sensation de vision floue dans un cas (2) en flexion drop attacks dans un cas vertiges et sensation de vision floue dans un cas (3) en rotation et flexion drop attacks dans un cas accentuation des troubles cerebello-vestibulaires dans un cas

Nous avons retenu deux cas parmi les plus demonstratifs des modifications du flux sanguin pendant les mouvements de la tete

Cas 1 Un homme age de 23 ans Debut il y a 6 ans par céphalees occipitales vertiges rotatoires troubles de l équilibre aggravés par les mouvements de rotation de la tete vers la gauche

Les tomographies de la charniere montraient une assimilation de l atlas une impression basilaire importante fusion incomplete entre C2 et C3

L arteriographie vertebrale bilaterale montrait une asymétrie des arteres vertebrales à

droite, le calibre de l artere etait réduit à *gauche il était* plus important Pendant le mouvement de rotation de la tete *vers la gauche* le flux sanguin de l artere vertebrale droite etait interrompu a la jonction V2—V3 (Fig 1, a et b) Cette meme rotation ne montrait pas de modification du flux sanguin de l artere vertébrale gauche (Fig 1c)

Cas 2 Une femme, agee de 31 ans depuis 3 ans presentant des crises d obnubilation de la conscience, des *vertiges rotatoires* et un flou de la vision pendant la flexion exagere de la tete

Les *tomographies* de la charniere cranio vertébrale montraient une impression basilaire avec occipitalisation *de l atlas* L artériographie vertebrale gauche montrait en position normale que le *contraste passait* assez bien dans le tronc basilaire (Fig 2a) en extension que le contraste passait beaucoup *mieux dans le* tronc basilaire qui se visualise parfaitement en Fig 2b et en flexion *que le contrast* n injectait pas le tronc basilaire (Fig 3c)

Le premier cas est un *exemple de l influence* des mouvements de rotation de la tête sur la dynamique circulatoire vertebro-basilaire

L *accentuation des troubles* neurologiques est due, a notre avis, au mecanisme pathogenique suivant l hypertrophie de l artere vertebrale gauche ne permet pas de compenser l insuffisance vertebrale droite dans les mouvements de rotation de la tete vers la gauche

L autre cas illustre l influence du mouvement de flexion de la tête

Le flux sanguin n a pas ete perturbe par les mouvements de rotation, de flexion ou d extension de la tête dans la serie de contrôle de 15 cas sans lesions de la charniere cranio-vertebrale

RÉSUMÉ

Étude morphologique et dynamique de la circulation vertébro basilaire de vingt cas de *malformation* de la charniere cranio vertébrale avec ponction percutanée de l artere brachiale L aspect et la fonction des arteres sont anlyses dans les différents positions de la *tete et du cou Des* modification du flux sanguin ont ete observés plus souvent au niveau de la charniere et *expliquent dans la* majorite des cas la *symptomatologie*

SUMMARY

The vertebro basilar circulation was studied morphologically and dynamically by puncture of the brachial artery in twenty cases of malformation of the craniovertebral joint The appearance and functioning of the arteries are analysed in relation to the different positions of head and neck Blood flow changes were observed more frequently at the level of the craniovertebral joint which in the majority of cases corroborated with the symptomatology

ZUSAMMENFASSUNG

Die vertebro basilare Zirkulation wurde morphologisch *und dynamisch* bei perkutaner Punktion der A brachialis in zwanzig Fallen von Missbildung des craniovertebralen Gelenks studiert Die Arterien werden mit Hinsicht auf ihre Erscheinung und Funktion bei ver

schiedener Haltung des Kopfes und Halses analysiert Blutflußstorungen wurden am haufig sten auf dem Niveau des craniovertebralen Gelenks observiert was in den meisten Fallen die Symptomatologie erklaren durfte

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OCCLUSION DES ARTÈRES CEREBRALES EN RAPPORT AVEC LESIONS EXPANSIVES INTRACRANIENNES

par

J Sole Llenas E Tolosa et P Fuenmayor

Si bien que quelques auteurs ont publie diverses observations d occlusions vasculaires produites par processus expansifs intracraniens, il faut remarquer que la presence d une obstruction arterielle est rare, en depit du nombre de lesions qui compriment ou englobent les vaisseaux cerebraux

Nous avons revise notre casuistique et nous avons pu constater l infrequence des occlusions arterielles en rapport avec les tumeurs cerebrales et les abces malgre la tendence de quelques meningiomes et cholesteatomes a comprimer et stenoser les vaisseaux voisins

Nous presentons deux cas etudies angiographiquement, et chirurgicalement verifies que nous croyons interessants par le fait de l occlusion et aussi du point de vue de la presence d une circulation collaterale anastomotique etablie

Observations

Cas I Malade d 49 ans atteint d une tumeur (un meningiome) du sinus caverneux droit d une evolution de 3 ans et caracterisee cliniquement par une paralysie partielle de la troisieme paire paralysi des quatrieme et sixi me paires de douleurs dans le domaine de la branche ophtalmique et diminution du reflexe corneen droit deuxieme paire non atteinte

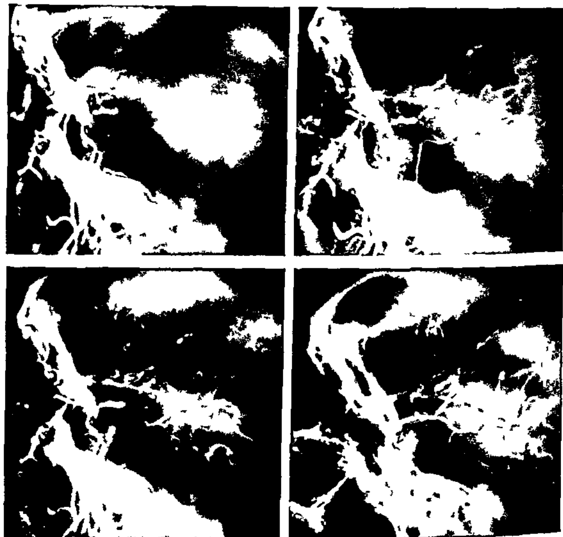


Fig 1 Cas 1 Tumeur parasellaire droite avec occlusion du siphon carotidien et circulation collaterale à travers l artere meningee moyenne et ophtalmique

L exploration angiographique (Fig 1) démontre une tumeur parasellaire de la taille d une olive qui incorpore la portion intracaverneuse du siphon carotidien et arrive a retrécir ou a obstruer completement la lumiere du vaisseau au niveau de son genou (Fig 1a) Grace a la circulation collaterale a travers l artere meningée moyenne et ophtalmique l irrigation sanguine se retablit au niveau de la carotide supraclinoidienne et on obtient une bonne injection de la cerebrale moyenne L etude des clichés seriographiques démontrent que la circulation collaterale a travers l ophtalmique procede presque exclusivement de la meningee moyenne qui passe de la cavité cranienne a l orbite pour s anastomoser avec une branche de l ophtalmique et aboucher finalement a ce vaisseau (Fig 1 b et c)

Quelques autres *faits angiographiques* sont a remarquer dans ce cas L arteriographie de la carotide gauche visualise les deux cerébrales anterieures complétant ainsi la revascularisation de l hémisphere droit Les résultats de l examen angiographique des carotides droite et



Fig ? Cas 2 a) Pneumoencephalogramme en projection anteroposterieure avec deplacement vers la droite du systeme ventriculaire par un processus expansif temporale gauche b) L arteriogramme carotidienne montre l obstruction de l artère cerebrale moyenne et la revascularisation de ses branches sylviennes

gauche avec compression de l artere controlateral n indiquent qu un certain degre d efficacité d la communicante antérieure Le systeme vertebro-basilaire ne prend aucune part a la comp nsation de l o clusion carotidienne droite

C s faits demontrent l efficacite dans ce cas de la cir ulation collaterale a travers les arteres meningee moyenne et ophtalmique car bien que dans les conditions habituelles elle ne contribue qu a l irrigation de la cerebrale moyenne elle peut dans certaines occasions fournir du flux sanguin à la cerebrale antérieure homolaterale et meme a l hemisphere controlaterale

Cas ? Malade de 19 ans qui presente un syndrome d hypertension *intracranienne* sequelle d une meningite tuberculeuse Il n existe pas de symptomes focaux du cote des hemispheres cerébraux

I encephalo raphie montre la presence d une lesion expansive temporale gauche avec deplacement v rs la droite du complexe ventriculaire et retrecissement du ventricule lateral gauche (Fig ?a)

La projection sagittale de l artériographi carotidienne gau h montre paradoxalement que la pericalleu e se trouve sur la ligne moyenne et que l artere sylvienne est obstruee et réduite a l état d une fin branche (Fig 2b) Son territoire de distribution se trouve revascularisé à travers le systeme de la *carotide externe* et plus conc tem nt de l artere meningee moyenne ce qui apparait confirmé par les projections laterales (Fig 3 a et b)

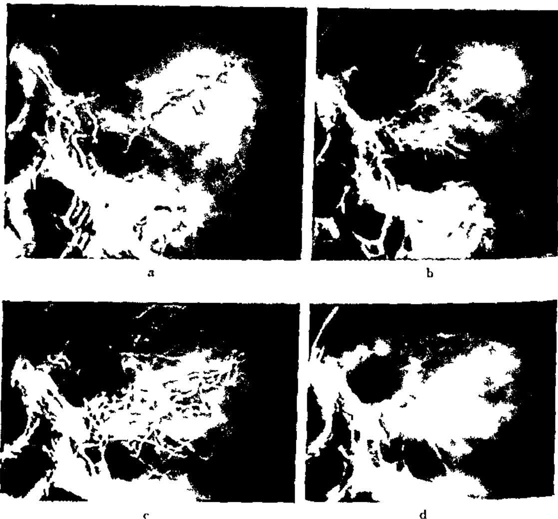


Fig 3 Cas 2 Opacification des branches de l'artère sylvienne à travers la meningée moyenne et *rete mirabile* Les clichés (b) et (c) montrent aussi la participation des rameaux des cérébrales antérieure et postérieure et de la choroïdienne antérieure à la revascularisation du territoire de l'artère sylvienne

qui montrent que la revascularisation du territoire de la cérébrale moyenne s'effectue initialement à travers la meningée moyenne et rete mirabile Dans les phases plus tardives on voit que des rameaux provenant de la cérébrale postérieure de la cérébrale antérieure et même de la choroïdienne antérieure contribuent aussi à la circulation collatérale (Fig 3 b et c) L'opacification de la lésion sylvienne persiste dans le phlébogramme (Fig 3d)

A l'opération on trouvait la dure mère adhérente au cortex au niveau de la scissure de Sylvius Après la résection d'une aire de cortex frontal on exposait un volumineux abcès multiloculaire frontotemporal profondément encré dans la scissure avec sa face externe fusionné aux vaisseaux sylviens déjà obstrués et englobés par la paroi de l'abcès L'extirpation de la lésion produit un important saignement qu'obligea à clipper les gros rameaux initiales de la cérébrale moyenne

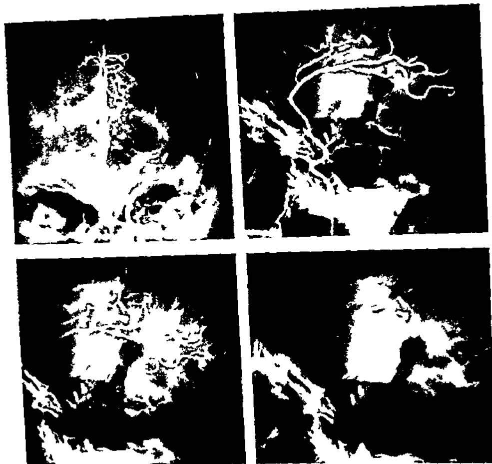


Fig 4 Cas 2 Angiographie carotidienne gauche postoperatoire La projection anteroposterieure et laterale montrent maintenant que la circulation collaterale provient exclusivement des artères cerebrales anterieure et posterieure et de la choroidienne anterieure mais non de la méningée moyenne qui a ete clippe pendant l'operation

Examen histologique granulome tuberculeux pas de defauts neurologiques focaux postoperatoires

Des mois plus tard on fit une *nouvelle exploration angiographique* L'angiographie carotidienne gauche montre a present que la circulation collaterale qui compense l'obstruction de la cerebrale moyenne provient des cerebrales anterieure et posterieure et de la choroidienne anterieure mais pas de la méningée moyenne car ce vaisseau a ete interrompu en incissant la dure mere et en la renversant pour exposer la lesion (Fig 4) L'arteriographie de la vertebrale montre la participation de la cerébrale posterieure dans la revascularisation

Quelques images de l'angiographie préoperatoire (Fig 3b) presentent certaines ressemblances a ec les arteriographies de la carotide externe dans les cas de méningiomes de

la convexité quand on constate que la vascularisation de la tumeur provient tout au moins en partie de la meningee moyenne

On ne peut cependant pas comparer les deux cas Dans les meningiomes implantes sur la dure mere, on comprend donc que son irrigation provienne directement des arteres meningees En echange, dans notre cas, la lesion ne contactait pas la dure mere et se trouvait completement submergee sous le cortex cerebral, dans la profondeur de la scissure de Sylvius Dans ces circonstances l arrivee du contraste a la lesion implique la revascularisation du territoire sylvien aux depens de la meningee

Conclusion

La confrontation de ces deux observations montre que la circulation collaterale s etablie principalement a travers de l artere meningee moyenne, meme dans le cas d occlusion de la sylvienne

Le *mecanisme occlusif* est *probablement different dans chacun* de ces deux cas Dans le premier malade nous supposons qu il a lieu par compression et strangulation du vaisseau englobe dans le tissu tumoral Par contre, dans le second cas, l existence d une *thrombose* est *bien* possible, si nous tenons compte de la frequence de cette lesion entre les sequelles de la meningite tuberculeuse

RÉSUMÉ

Les auteurs presentent deux cas d occlusion d arteres cerebrales due a des lesions expansives intracraniennes ces cas ont éte étudies angiographiquement et vérifies chirurgicalement Le mecanisme occlusif etait différent dans ces deux cas Dans le premier cas l occlusion du siphon carotidien etait due à la compression de ce vaisseau qui etait englobe dans la tumeur Dans le second cas l occlusion de l artere sylvienne était probablement due a une thrombose La circulation collaterale anastomotique s etait etablie principalement par l artere méningee moyenne

SUMMARY

Two cases of expansive intracranial lesions with occlusion of the cerebral arteries are presented Angiography was performed in both cases and the diagnoses were confirmed by operation The cases differed with respect to the mechanism of occlusion In th first case o clusion of the carotid siphon was due to compression of the vessel which was surrounded by *the tumour* In the second case occlusion of the sylvian artery was probably due to thrombosis The collateral circulation was mainly established by anastomosis from the middle meningeal artery

ZUSAMMENFASSUNG

Es wird über zwei Fälle von intrakraniellen expansiven Läsionen mit Okklusion der Gehirnarterien berichtet. Beide wurden angiographisch untersucht und die Befunde wurden bei der Operation bestätigt. Der Verschlussmechanismus war in den beiden Fällen von verschiedener Art. Die Okklusion des Carotissiphons wurde im ersten Falle durch die Kompression des vom Tumor umschlossenen Gefässes verursacht. Im zweiten Falle war wahrscheinlich eine Thrombose die Ursache der Okklusion der Arteria cerebralis media. Die kollaterale Zirkulation wurde hauptsächlich durch eine Anastomose von der Arteria meningica media sichergestellt.

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Conclusion

La confrontation de ces deux observations montre que la circulation collatérale s'établit principalement à travers de l'artère méningée moyenne, même dans le cas d'occlusion de la sylvienne.

Le mécanisme occlusif est probablement différent dans chacun de ces deux cas. Dans le premier malade nous supposons qu'il a lieu par compression et strangulation du vaisseau englobé dans le tissu tumoral. Par contre, dans le second cas l'existence d'une thrombose est bien possible, si nous tenons compte de la fréquence de cette lésion entre les séquelles de la méningite tuberculeuse.

RÉSUMÉ

Les auteurs présentent deux cas d'occlusion d'artères cérébrales due à des lésions expansives intracraniennes; ces cas ont été étudiés angiographiquement et vérifiés chirurgicalement. Le mécanisme occlusif était différent dans ces deux cas. Dans le premier cas l'occlusion du siphon carotidien était due à la compression de ce vaisseau qui était englobé dans la tumeur. Dans le second cas l'occlusion de l'artère sylvienne était probablement due à une thrombose. La circulation collatérale anastomotique s'était établie principalement par l'artère *méningée moyenne*.

SUMMARY

Two cases of expansive intracranial lesions with occlusion of the cerebral arteries are presented. Angiography was performed in both cases and the diagnoses were confirmed by operation. The cases differed with respect to the mechanism of occlusion. In the first case occlusion of the carotid siphon was due to compression of the vessel, which was surrounded by the tumour. In the second case, occlusion of the sylvian artery was probably due to thrombosis. The collateral circulation was mainly *established by anastomosis* from the middle meningeal artery.

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DIAGNOSTIC VALUE OF CATHETER VERTEBRAL ANGIOGRAPHY

Review of 250 examinations

by

MUTSUMASA TAKAHASHI, GABRIEL WILSON and WILLIAM HANAFEE

Vertebral angiography has in recent years become a routine diagnostic procedure at many medical centers Although various methods have been proposed, there does not appear to be a standard method which is widely employed Techniques proposed in the literature include direct percutaneous puncture of the vertebral arteries (LINDGREN 1950, SUGER, HOLDEN & POWELL 1949, KRAYENBUHL & YASARGIL 1967, YASARGIL 1962), retrograde studies by injection into the right common carotid arteries (MONES 1961), injection into the subclavian arteries by a catheter (WEIBEL 1966) or needles (BARBIERI & VERDECCHIA 1957) and retrograde injection of contrast media into the brachial arteries (GORE, TINDALL & ODOM 1964, GOULD, PEYTON & FRENCH 1955)

Selective catheterization of the vertebral arteries was first developed by RADNER (1947, 1951) and HAUGE (1954) who used surgical exposure of the radial arteries This time consuming technique however, required considerable experience LINDGREN (1956), BONTE, RIFF & SPY (1958) and CRONQVIST (1961) evolved selective catheterization of the left vertebral artery via the femoral arteries, but satisfactory catheterization was not consistently obtained in patients above 50 years of age More recently, HANAFEE (1963) and NEWTON (1963)

Table 1

Age and sex distribution in the group of 227 patients investigated

Age	Total	Male	Female
0—9	12	7	5
10—19	25	19	6
20—29	28	15	13
30—39	35	20	15
40—49	57	33	24
50—59	46	25	21
60—69	22	11	11
70—	2	0	2
	Total 227	130	97

Table 2

Results obtained with different techniques on vertebral angiography in 227 patients performed on 250 occasions

Technique employed	Number of successful examinations	Number of unsuccessful attempts
Catheterization of right vertebral artery via right axillary artery	95	18
Catheterization of left vertebral artery via left axillary artery	16	9
Catheterization of right vertebral artery via femoral artery	27	4
Catheterization of left vertebral artery via femoral artery	94	11
Subclavian injection	4	1
Technique not stated	6	—
Successful study not obtained	(8)	(—)

used the selective catheterization technique via the axillary approach. In our experience selective catheterization via the axillary or femoral arteries provides a safe and relatively simple means of studying the vertebrobasilar circulation.

The purpose of this paper is to describe and evaluate our experience and emphasize the value of this technique in the diagnosis of posterior fossa expanding lesions. The technique has been described in detail elsewhere (TAKAHASHI et coll. 1967).

Material and Methods. The subject material for this study comprises 250 consecutive catheter vertebral angiographic examinations in 227 patients performed at the UCLA Medical Center from April 1962 to March 1967. Vertebral angio-

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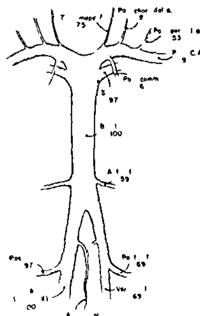


Fig 1 Percentage demonstration of the branches of th vertebrobasilar system

Post inf c a	—	Posterior inferior cerebellar artery
Ant inf c a	—	Anterior inferior cerebellar artery
Sup c a	—	Superior cerebellar artery
Post comm A	—	Posterior communicating artery
Post C A	—	Posterior cerebral artery
Post perical a	—	Posterior pericallosal artery
Post choridal a	—	Posterior choroidal artery
Thalamoperf a	—	Thalamoperforate artery

grams not intended for studying the intracranial vessels were excluded from this investigation Three patients were examined 3 times, 17 patients twice and the remaining 207 patients once Age and sex distribution of the patients appear in Table 1

Roentgenograms, reports and case histories of all the patients were reviewed Techniques used for successful and unsuccessful catheterization were tabulated Percentage visibility of branches and tributaries of the posterior fossa vessels was computed Complications and the comparative value of vertebral angiography were also evaluated The angiographic impression gained in the course of the clinical evaluation of a patient, as reported in the roentgen consultation sheet, was considered as the angiographic diagnosis rather than the retrospective diagnosis

Most of the patients were investigated for tumors, vascular malformations, occlusive disease and aneurysms in the posterior fossa A small number of patients were studied to supplement carotid angiographies, especially in the presence of occipital tumors and extracranial tumors

Results

The different techniques used are given in Table 2 Satisfactory results were obtained in 238 of 250 studies (95 2 %) with selective catheterization of the vertebral artery and in 4 with subclavian injections (1 6 %) In 8 patients (3 2 %) successful studies were not obtained

Fig 2 Percentage demonstration of the tributaries of the venous system in the lateral projection

Int C V	— Internal cerebral vein
Ant pontomes v	— Anterior pontomesencephalic vein
Lat mes v	— Lateral mesencephalic vein
Precentral c v	— Precentral cerebellar vein
Sup verm v	— Superior vermian
Inf verm v	— Inferior vermian vein
Po t inf c v	— Posterior inferior cerebellar vein

The vertebral artery could not be successfully catheterized at 43 attempts because of narrowing of the orifice or tortuosity of the proximal vertebral artery, but these difficulties were overcome by another route except for 12 instances when satisfactory studies were not obtained or subclavian injection was utiliz-d

The incidence of identification of specific arterial branches of the vertebrobasilar system is shown in Fig 1 Numbers indicate percentage demonstration Reflux of contrast medium down the contralateral vertebral artery was seen in almost 70 % The study was not considered satisfactory unless the contralateral vertebral artery together with the posterior inferior cerebellar artery was demonstrated If this did not occur catheterization of the contralateral artery was usually performed

Schematic diagrams of the venous phase in the lateral and half axial projections are shown in Figs 2 and 3 Important veins in the diagnosis of posterior fossa tumors uch as the precentral cerebellar vein superior vermian vein anterior pontomesencephalic vein and the petrosal vein were demonstrated in a fairly high percentage of cases

The diagnostic accuracy is shown in Table 3 There were six false negatives which were originally interpreted as negative but proved to harbor a lesion There were two medullopontine tumors one each of cerebellar metastasis fourth ventricle ependymoma Arnold Chiari malformation and cerebellopontine angle tu mor Two additional cases were false positives Angiograms in these two cases were interpreted as demonstrating a medullopontine tumor and an occipital tumor but no tumor was found at encephalography or surgery Diagnostic accuracy for posterior fossa tumors was higher than usually expected

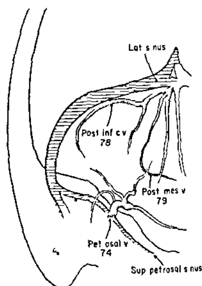


Fig 3 Percentage demonstration of the tributaries of *the venous system in the half axial projection*

Lat sinus	— Lateral sinus
Post inf c v	— Posterior inferior cerebellar vein
Post mes v	— Posterior mesencephalic vein
Sup petrosal sinus	— Superior petrosal sinus

Complications

Neurologic complications were encountered in 8 of 250 vertebral artery examinations As has been reported by others (LESTER & KLEE 1965, SCATLIFF, MISHKIN & HYDE 1965), complications of catheter vertebral arteriography are relatively rare The neurologic complications seen in this series of 250 angiographies were as follows

Permanent

Quadriplegia at the C4—5 level, probably due to transverse myelitis	1

Temporary

1 *Convulsion lasting 15 minutes*	1
2 Visual hallucination and disorientation lasting less than 24 hours	4
3 Mild hemiparesis lasting less than 48 hours	2
Total	8

There were seven transient complications Visual hallucination and mild disorientation were the most frequent transient complications, but cleared in 24 hours Two patients with mild hemiparesis recovered within 48 hours There was one patient with a *convulsion of short duration There was one* permanent complication in a 15 year old boy who was studied angiographically for an extensive juvenile angiofibroma for the third time Vertebral angiography was performed

Table 3

Results of 250 vertebral angiographies in 227 patients

Angiographic diagnosis	Number of examinations	Number of patients	Number of errors
Normal	138	129	6
Tumor	59	51	2
Vascular lesions	38	33	—
Others	7	7	0
Substandard exams	8	7	—
Total	250	227	8

Table 4

Comparison of vertebral angiography and encephalography in 67 patients

Pathologic or final diagnosis	Total number	Examination	Angiographic or pneumographic diagnosis		
			Normal	Equivocal	Abnormal
Normal	32	Vertebral angiography	28	3	1
		Pneumography	32	0	0
Posterior fossa tumors	21	Vertebral angiography	5	2	14
		Pneumography	0	4	17
Supratentorial tumors	10	Vertebral angiography	3	2	5
		Pneumography	1	1	8
Vascular lesions	4	Vertebral angiography	0	0	4
		Pneumography	3	0	1

via the right femoral artery and an injection was made into each vertebral artery following bilateral carotid angiography. During catheterization of the left vertebral artery the catheter entered the thyrocervical trunk and two or three test injections of 3 to 4 ml of 60 % methylglucamine iothalamate were made. The patient developed quadriplegia at 24 hours. This complication might be due to transverse myelitis secondary to injection into the thyrocervical trunk since this artery supplies the cord at this level.

Local complications at the sites of arterial punctures were infrequent and not serious in this series. Hematomas in the groin or axilla always subsided without surgical evacuation. Infrequent occurrence of hemiparesis of the arm usually cleared as the anesthetic was absorbed. Allergic reactions and hypotensive reac

tions were encountered occasionally but were never serious Subintimal injection or elevation of an atherosclerotic plaque by the catheter tip have been very rarely encountered and no serious neurologic signs and symptoms were attributed to them It is our practice to advance the catheter with a leading guide wire to avoid injury to the intima

The comparative value of catheter vertebral angiography is presented in 67 patients in whom both vertebral angiography and encephalography or ventriculography were performed (Table 4) Seventeen of twenty one posterior fossa tumors were correctly localized by pneumography while fourteen tumors were correctly localized by vertebral angiography All the thirty four normal cases were interpreted as normal on encephalography but four were interpreted as equivocal or abnormal on vertebral angiography Four vascular lesions were correctly diagnosed by vertebral angiography but three lesions were missed by encephalography One case with an aneurysm of the posterior inferior cerebellar artery presented as a fourth ventricular tumor

Discussion

Although retrograde brachial and subclavian injections have certain advantages, consistently successful angiograms of good quality can not be obtained by these indirect methods In order to obtain excellent vascular filling, selective injection into the vertebral artery is mandatory Other disadvantages of the indirect methods include (1) the inevitable use of larger volumes of contrast media, (2) there is usually overlapping of the carotid and vertebral systems which prevent accurate identification of small vessels of the vertebral systems, (3) reflux of contrast media down the contralateral vertebral artery is rarely seen with the indirect methods and it is sometimes necessary to perform contralateral vertebral angiography to demonstrate the posterior inferior cerebellar artery

Therefore, it appears that direct needle puncture or selective catheter vertebral angiography are distinctly better methods to demonstrate abnormalities in the posterior fossa Direct needle injection of vertebral arteries has been widely used with considerable success at many institutions This method has the great advantage that the examination can be performed in a relatively short time if made by an experienced examiner Direct needle puncture of the vertebral artery can also be performed without the use of a TV fluoroscopic unit

Direct needle puncture of the vertebral artery however, is associated with trauma to the vertebral artery, such as subintimal injections SCATLIFF, MISHKIN & HYDE (1965) reported extravasation and subintimal injections of contrast media in 50 % of the cases studied by needle puncture On the other hand,

catheter vertebral angiography is accompanied by almost no trauma to the vertebral arteries. Reflux down the contralateral vertebral artery occurs in approximately 70 %, while the direct puncture technique gives results of 20 % to 50 % depending upon the experience of the examiners (SCATLIFF, MISHKIN & HYDE 1965). In addition, the catheter technique can be performed at the same sitting with carotid angiography. General anesthesia is usually required for direct needle studies but the catheter method does not require general anesthesia unless the patient is uncooperative or a child under 16 years of age. Another disadvantage of direct methods is the fact that the size of vertebral arteries is quite unpredictable and direct puncture of the same vessel may be attempted repeatedly in spite of a small vertebral artery. With the catheter technique the catheter is switched to the contralateral side when hypoplasia or occlusive disease is demonstrated on a test injection. The rate of success in our series is 95.2 % while the success rate of direct methods ranges from 70 % to 88 % (SJOGREN 1953, MONES 1961, LESTER & KEFE 1965 and SCATLIFF, MISHKIN & HYDE 1965). One potential danger of the catheterization method is plugging of the vertebral artery but careful manipulation of the catheter and test injections of the contrast medium under fluoroscopy minimize this danger. There were only eight patients who developed neurologic complications in this series of 250 examinations. Arterial spasm was quite uncommon with the catheterization method.

It has been frequently maintained that vertebral angiography is less important in the diagnosis of posterior fossa tumors but as has been shown in this report, posterior fossa tumors and some supratentorial tumors can be diagnosed with quite high accuracy notwithstanding absence of tumour vessels or accumulation of contrast material within the lesion. If there is a reluctance to perform pneumography in patients with increased intracranial pressure, vertebral angiography offers an alternate method of investigation. When an encephalogram is inconclusive, vertebral angiography will give supplemental or confirmatory information.

SUMMARY

Two hundred and fifty catheter angiographic examinations of the vertebral artery via the femoral or axillary arteries were reviewed and the value of this technique is emphasized.

ZUSAMMENFASSUNG

Zweihundert fünfzig Katheterangiographien der Arteria vertebralis via A. femoralis oder A. axillaris wurden retro pektiv studiert. Der Wert dieser Technik wird betont.

RÉSUMÉ

Les auteurs ont passé en revue 250 angiographies vertébrales par cathétérisme des artères fémorale ou axillaire et soulignent l'intérêt de cette technique

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L'ANGIOGRAPHIE SELECTIVE PER OPERATOIRE DANS LES TUMEURS CEREBRALES HEMISPHERIQUES

par

B VLAHOVITCH PH FREREBEAU G OUAKNINE M BILLET et CL. GROS

L angiographie selective des petites arteres cerebrales a ete realisee sur plus de 50 cas de tumeurs hemispheriques depuis 1966 Cette technique a ete appliquee dans le double but de preciser le diagnostic topographique et l extension des tumeurs cerebrales et de permettre un traitement chimiotherapique local Elle contribue egalement a la connaissance de l hemodynamique corticale L angiographie selective et la chimiotherapie ont ete utilisees dans les gliomes malins avec une bonne tolerance

Contribution au diagnostic topographique des tumeurs

Le catheterisme arteriel l injection de produit de contraste et la prise des clichés radiographiques Le catheterisme est realise sur des arteres de calibre submillimetrique Le choix de l artere se fait sur deux criteres principaux soit une artere qui se rend visiblement a la tumeur soit une artere qui traverse un plan de coupe prevu pour une lobectomie L arteriole catheterisee etant destinee a etre definitivement interrompue en fin d intervention En general pour une meme artere on realise un double catheterisme dans le sens du courant sanguin (catheterisme anterograde et a contre courant (catheterisme retrograde) Ce procede permet d obtenir une visualisation du territoire cortical correspondant a la collaterale arterielle et egalement une opacification de tout le pedicule vasculaire d origine de cette collaterale

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CLINIQUE NEURO CHIRURGICALE (PROF CL GROS) DU C H U MONTPELLIER, FRANCE

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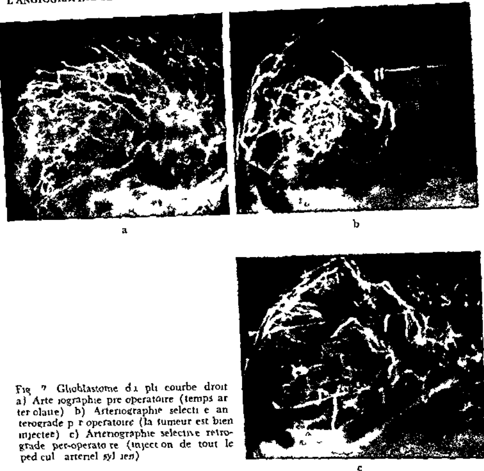
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a b c

Fig 7 Glioblastome du pli courbe droit a) Arteriographie pre operatoire (temps arteriolaire) b) Arteriographie selective anterograde per operatoire (la tumeur est bien injectee) c) Arteriographie selective retrograde per-operatoire (injection de tout le pedicule arteriel sylvien)

tion pathologique se retrouvent avec plus de *precision* Dans les cas de metastases on voit se former des ombres vasculaires a contours bien limites qui permettent facilement de faire le diagnostic Il arrive souvent que la tumeur ainsi visualisee apparait comme amputee d une partie plus ou moins grande de son contour (Fig 1b) Cela indique que la vascularisation de la masse tumorale est aussi sous la dependance d un secteur vasculaire *voisin* Cet inconvenient est facilement rattrape par l utilisation jumelee *de l arteriographie* selective retrograde

L arteriographie selective retrograde L injection de produit de contraste dans l extremite proximale de l artere catheterisee permet l opacification de l ensemble des collaterales d un meme pedicule arteriel sylvien ou cerebral anterieur Cette maniere de proceder permet de voir toute la tumeur et de discerner a quel



Fig. 1. Glioblastome parietal droit. a) Arteriographie pre-operatoire. b) Arteriographie selective per-operatoire anterograde.

Le produit de contraste utilise est la substance triiodee de l'angiographie cerebrale de routine. Les doses employees varient de 2 à 4 ml. La prise des cliches necessite l'adjonction sur la têtiere de la table d'operation d'un porte cassettes. Les cliches sont pris aussi bien en incidence de face que de profil. L'utilisation d'un seriographe n'est pas exclue mais n'a pas ete faite dans nos cas.

L'arteriographie selective anterograde. Elle opacifie le territoire vasculaire de l'arteriole catheterisee que l'on peut appeler « secteur vasculaire cerebral ». Le drainage veineux de ce territoire est en general multiple. On distingue des veines superficielles mais egalement pour certaines localisations (frontale ou du carrefour ventriculaire) des veines allant se jeter dans le systeme de Galien.

La masse tumorale est en general visualisee avec une nettete incomparablement superieure a celle de l'arteriographie preoperatoire habituelle (Fig. 1 et Fig. 2). Cette opacification directe met en evidence des details totalement insoupçonnes, aussi bien sur l'emplacement de la tumeur que sur l'aspect des vaisseaux pathologiques. Une des principales caracteristiques de l'image est la distorsion curviligne des arterioles qui se voit quel que soit le type tumoral. Ceci temoigne du caractere expansif de la lesion. Cet aspect existe isolement, dans les gliomes benins ou kystiques.

Dans les tumeurs malignes, les differentes formes bien connues de vascularisa

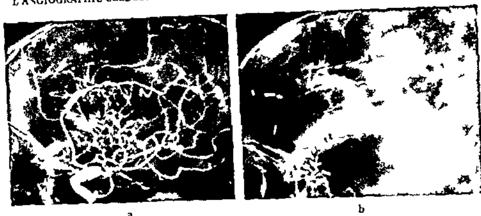


Fig 4 Glioblastome fronto-calleux droit a) Artériographie pré-opératoire b) Artériographie sélective antérograde au troisième jour post-opératoire faite par le même cathéter de l'infusion cytostatique

artériel laissé à demeure Le fait que l'angiographie sélective des vaisseaux corticaux n'opacifie jamais les artères des noyaux gris centraux autorise l'utilisation de doses assez importantes de substance cytostatique

Chimiothérapie locale extemporanée Lors de l'opération après visualisation de la tumeur par l'angiographie sélective une injection de méthotrexate est réalisée à la dose de 20 mg dilué dans 10 ml de sérum physiologique Cette injection peut entraîner quelquefois un oedème local assez net L'exérèse est pratiquée une demi heure environ après Une étude biopsique est faite avant et après la chimiothérapie

Chimiothérapie locale post opératoire Elle a été pratiquée chez 3 malades où la tumeur ne pouvait être entièrement enlevée soit à cause d'une impossibilité technique soit encore à cause de l'importance fonctionnelle du siège de la lésion

Dans un cas, il s'agissait d'une tumeur du corps calleux propagée au lobe frontal droit dont l'exérèse par lobectomie n'a pu être que partielle La chimiothérapie faite pendant 5 jours intéressait directement le reste tumoral situé dans le corps calleux elle a été contrôlée par artériographie sélective post-opératoire (Fig 4) Ce malade a été perdu de vue 3 mois après. Dans les deux autres cas il s'agissait de glioblastomes récidivants du carrefour ventriculaire gauche La substance utilisée était le cyclophosphamide Dans un de ces cas on a pu enregistrer une survie d'un an et demi

Une étude détaillée des résultats de cette chimiothérapie locale reste prématurée faute de recul suffisant La tolérance de la méthode est bonne

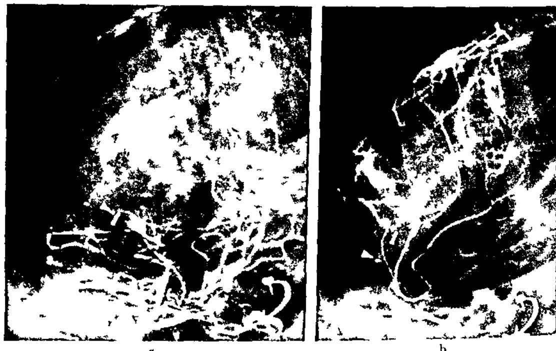


Fig. 3. Glioblastome frontal gauche de la convexité. a) Artériographie sélective rétrograde du pédicule sylvien (la tumeur n'est pas injectée). b) Artériographie sélective rétrograde du pédicule cérébral antérieur (la tumeur est bien opacifiée).

pédicule elle doit son irrigation principale. Cette indication est précieuse pour les sièges tumoraux des territoires vasculaires frontières.

Bien souvent, dans la région de la convexité frontale, existent des tumeurs sous la dépendance exclusive du pédicule artériel cérébral antérieur alors que l'inspection simple aurait pu les rattacher en partie ou en totalité à l'irrigation sylvienne (Fig. 3). Cette information ne peut en aucune manière être fournie par l'angiographie de dépistage pré-opératoire.

L'exérèse neuro-chirurgicale peut ainsi être guidée plus directement sur la lésion, en épargnant au maximum la destruction de zones cérébrales saines.

On peut également pratiquer des variantes techniques permettant de canaliser le produit de contraste, dans une angiographie rétrograde, vers une direction déterminée par un clip de Mayfield (angiographie rétrograde partielle, Fig. 5).

Contribution du cathétérisme artériel per-opératoire au traitement chimiothérapique local des tumeurs cérébrales

L'emploi d'une chimiothérapie intra-artérielle a été réalisé dans 15 cas. Deux méthodes ont été utilisées, soit injection extemporanée per-opératoire, soit infusion de cytostatiques post-opératoire pendant 3 à 5 jours, par le cathéter intra

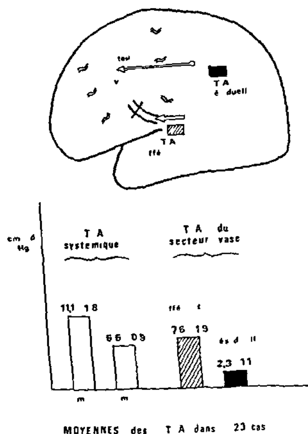


Fig 6 Analyse comparative de la tension arterielle systemique et des tensions arterielles afferente et residuelle d un secteur vasculaire cerebral

afferente du secteur est interrompue les secteurs vasculaires limitrophes contribuent par les anastomoses a l irriguer realisant un veritable « steal sanguin »

Le regime circulatoire d un secteur vasculaire cerebral apres deafferentation de son artere principale Lors du catheterisme d une artere sub millimetrique pour angiographie selective l enregistrement des pressions arterielles se fait sur l extremite proximale de l artere (pression arterielle afferente du secteur) et sur l extremite distale (pression arterielle residuelle du secteur) (Fig 6)

La pression arterielle afferente d un secteur vasculaire cerebral est directement proportionnelle a la tension arterielle systematique elle est superieure pour le calibre indique de l artere (< 1 mm de diametre) a la pression diastolique

En moyenne dans 14 cas la pression afferente est de 7 6 cm de Hg ± 1 9 alors que la tension arterielle systemique est de 11 1 cm de Hg ± 1 8 pour la maxima et de 6 6 cm de Hg ± 0 9 pour la minima Les ecarts extremes de cette



Fig. 5. — Artériographie sélective rétrograde partielle peropératoire mettant en évidence une métastase et un secteur vasculaire cérébral.

Contribution à la connaissance de l'hémodynamique hémisphérique

L'angiographie sélective per-opératoire se pratique avec le concours d'un enregistrement polygraphique continu comportant l'électrocorticographie et la prise des tensions artérielles systémiques et artériolaires par capteur électronique.

Deux importantes caractéristiques de la circulation corticale sont ainsi mises en évidence : l'une concerne son organisation en secteurs vasculaires relativement autonomes, et l'autre le fonctionnement du régime circulatoire après déafférentation de l'artère principale d'un secteur.

Les secteurs vasculaires cérébraux (Fig. 5). L'artériographie sélective révèle que chaque artériole tient sous sa dépendance un territoire vasculaire dont la superficie maxima ne se modifie pas par la pression d'injection du produit de contraste. Le secteur vasculaire cérébral a des limites qui le séparent des secteurs voisins avec lesquels il reste uni par le système anastomotique corticopial. Les frontières d'un secteur vasculaire cérébral restent, à l'état normal, infranchissables, lui donnant ainsi une individualité physiologique. Par contre, lorsque l'artère

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JUGULARIS VENOGRAPHIE FÜR DIE DIAGNOSTIK VON RAUMFORDERNDEN INTRAKRANIELLEN PROZESSEN

von

SIGURD WENDE und KLAUS CIBA

In der vorliegenden Studie wird uber Gefassveranderungen im Bereich der Sinus cavernosi bei Geschwulsten der Sella Region berichtet Da die Sinus Darstellung nicht optimal ist wenn man die venose Phase bei Karotisarteriographie betrachtet wurde bei den eigenen Untersuchungen eine retrograde Kontrastmittel Injektion in die V jugularis durchgefuhrt Hiermit ist eine deutlich nachweisbare Kontrastmittelfullung der Sinus zu erreichen Ausserdem kommt es zu einer Darstellung des Plexus venosus pterygoideus und zu einer Abbildung der Plexus venosi vertebrales und der tiefen Halsvenen Um storende Überlagerungen durch Knochenstrukturen auszuschalten wurden die Rontgenaufnahmen im Substraktionsverfahren (Siemens-Subtraktionsgerät) ausgewertet

Untersuchungstechnik Nach percutaner Punktion der V jugularis am Hals wurden 30 ml Conray 60 unter hohem Druck manuell injiziert Gleichzeitig wurden Rontgenaufnahmen im seitlichen und sagittalen Strahlengang abgeschaltet

Befunde

Abbildungen 1 und 2 zeigen eine Darstellung der V jugularis die kraftige Kontrastmittel Fullung der tiefen Halsvenen und der Plexus venosi vertebrales

tension ont été trouvés dans 4 cas ; deux fois la tension artérielle *afférente* était égale à la tension artérielle systolique, deux fois elle était inférieure à la tension artérielle diastolique. Cette mobilité de la pression artérielle est expliquée par l'existence d'une vasomotricité locale des grosses artères cérébrales.

La pression résiduelle d'un secteur vasculaire cérébral, mesurée sur l'extrémité distale de l'artériole cathétérisée, est égale à 2,3 cm de Hg ± 1,1 la tension artérielle systémique étant de 10,8 cm de Hg ± 1,9 pour la maxima et 6,2 cm de Hg ± 1,1 pour la minima. Cette pression artérielle résiduelle est entretenue par le réseau anastomotique entourant le secteur vasculaire cérébral privé de son irrigation principale. La survie du parenchyme nerveux peut être assurée par cette circulation appauvrie comme le prouvent les enregistrements électrocorticographiques per-opératoires.

La pression artérielle résiduelle se révèle relativement indépendante de la tension artérielle systémique sauf pour les variations extrêmes de cette dernière. Par contre, elle augmente avec l'oedème cérébral local, même lorsque la tension artérielle systémique ne varie pas. La pression artérielle distale ou résiduelle d'un secteur cortical est un indice chiffré de la résistance vasculaire cérébrale.

RÉSUMÉ

L'angiographie sélective per-opératoire par cathétérisme des artères corticales sub-millimétriques a été utilisée sur plus de 50 cas de tumeurs hémisphériques avec une bonne tolérance. Cette technique apporte une information topograpique précieuse en révélant des *détails insoupçonnés sur une angiographie* pré-opératoire. Elle permet également d'utiliser une chimiothérapie cytostatique intra-artérielle locale. L'enregistrement des pressions intra-artérielles contribue à la connaissance de l'hémodynamique des secteurs vasculaires corticaux.

SUMMARY

Selective angiography during operation by means of catheterization of the minute cortical arteries was performed with good results in more than 50 cases of tumour of the hemispheres. Precise topographic information and details not demonstrable with pre-operative angiography can be achieved by means of this technique. It also allows local intra-arterial application of cytostatic chemotherapy and by registration of the intra-arterial pressure the hemodynamic conditions in the cortical vascular regions can be investigated.

ZUSAMMENFASSUNG

Selektive Angiographie während der Operation mittels Katheterisierung der kleinsten corticalen Arterien wurde mit guten Resultaten in mehr als 50 Fällen von Hemisphären-tumoren vorgenommen. Exakte topographische Information und Darstellung von Einzelheiten die mit pre-operativer Angiographie nicht möglich sind, können mit dieser Technik erhalten werden. Intra-arterielle zytostatische Chemotherapie kann lokal appliziert werden und bei Registrierung des intrakraniellen Druckes können die hämodynamischen Verhältnisse in den corticalen vaskulären Regionen klargelegt werden.

Abb 5 Jugularis-Venogramm bei einem Kranken mit einem Hypophysen-Tumor sagittaler Strahlengang

Abb 6 Jugularis-Venogramm bei einem Kranken mit einem Chordom sagittaler Strahlengang

der Sinus petrosus superior und inferior und die Sinus cavernosi und intercavernosi sind dargestellt

Bei Änderung des Strahlenganges bzw der Kopfhaltung entfällt die Überlagerung der einzelnen Gefässabschnitte so dass eine genaue Differenzierung der Gefässe möglich wird

Bei Kranken mit Hypophysengeschwülsten weisen die Sinus cavernosi eine deutliche Formveränderung auf Es finden sich eine Eindellung und Abflachung dieser Sinus von oben und vorn die bei parasellarer Ausdehnung des *Tumors* am deutlichsten sind (Abb 3 und Abb 4)

Wertet man die Röntgenaufnahmen im sagittalen Strahlengang aus so zeigen sich bei Hypophysentumoren auf der Seite des stärkeren Tumorwachstums eine mangelhafte Kontrastmittel-Füllung oder eine Eindellung des Sinus *cavernosus* Es wird damit also eine Bestimmung der Tumorausdehnung möglich (Abb 5)

Auch bei einem Kranken mit einem Chordom das sich suprasellar und parasellar nach links ausbreitete, ist ein ähnlicher Befund mit einer Eindellung des linken Sinus cavernosus erkennbar (Abb 6)

Die geschilderten Sinus-Veränderungen sind jedoch nur zu beobachten wenn ein raumfordernder Prozess im Sella oder Clivus-Bereich vorliegt Der Druck eines Grosshirntumors reicht nicht aus um *eine Eindellung* des Sinus cavernosus hervorzurufen

Wir glauben dass mit dieser einfachen Untersuchungsmethode, die den Kranken nicht belastet und keine Komplikationen aufweist, zusätzliche und wertvolle diagnostische Aussagen bei Geschwülsten der Sella Region möglich sind



Abb. 1. Normales Jugularis-Venogramm, seitlicher Strahlengang



Abb. 2. Normales Jugularis-Venogramm, seitlicher Strahlengang



Abb. 3. Jugularis-Venogramm bei einem Kranken mit einem Hypohysen-Tumor



Abb. 4. Jugularis-Venogramm bei einem Kranken mit einem Hypophysen-Tumor

den Sinus sigmoides und transversus. Auf der Abb. 1 ist ferner eine venöse Verbindung zwischen dem Sinus sigmoides und dem Vertebralgefäßsystem durch das Foramen mastoideum erkennbar. Auch der Plexus pterygoideus hat sich mit Kontrastmittel gefüllt. Die Sinus petrosi und der hintere und mittlere Abschnitt der Sinus cavernosi sind ebenfalls deutlich nachweisbar.

Auf den Röntgenaufnahmen im sagittalen Strahlengang bilden sich beide Jugularvenen ab (Einfluss und Ausfluss des Kontrastmittels). Der Sinus sigmoides und transversus ist bds. bis zum Confluens sinum zu übersehen. Auch



Abb 5 Jugularis-Venogramm bei einem Kranken mit einem Hypophysen-Tumor sagittaler Strahlengang



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ZUSAMMENFASSUNG

Mit der Jugularis-Venographie können die venösen Sinus im Sella-Bereich röntgenologisch dargestellt werden. Bei Geschwülsten dieser Region zeigen die Sinus cavernosi typische Formveränderungen.

SUMMARY

The venous sinuses in the sella region can be demonstrated radiographically by means of venography of the jugular vein. The cavernous sinus, in the presence of lesions in this region, shows characteristic changes in shape.

RÉSUMÉ

La phlébographie jugulaire permet de radiographier les sinus veineux de la région sellaire. Les sinus caverneux présentent des déformations typiques dans les tumeurs de cette région.

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PARADOXICAL ARTERIAL SHIFTS

by

SAMUEL M WOLPERT and ERNEST J FERRIS

It is a common neuroradiologic concept that anteriorly placed brain masses cause a greater displacement of the pericallosal artery than of the internal cerebral vein and that with posteriorly placed masses the reverse is generally true CURTIS (1951) states "lateral displacement of the internal cerebral vein should always be looked for in the a p phlebogram as it is of great lateralizing value if present particularly if there is no shift of the anterior cerebral artery Since then there have been numerous similar statements in the literature (JOHANSON 1954 ECKER & RIEMENSCHNEIDER 1955 MOKROHISKY et coll 1956 GREITZ & LINDGREN 1961 SCHECHTER 1964, and TAVERAS & WOOD 1964) However, the authors have seen cases of posteriorly placed tumors in which the displacement of the pericallosal artery has exceeded that of the internal cerebral vein Examples are here presented

Case reports

Case 1 A 69 year-old woman was admitted to the hospital for the investigation of headaches for the past year The headaches were accompanied with nausea and vomiting Neurologic examination was normal except for a minimal receptive verbal and writing



a



b



c

Fig 1 Left lateral carotid angiography a) Forward telescoping and separation of the peripheral branches of the middle cerebral artery with downward displacement of the terminal portion of the pericallosal artery and enlargement of the middle meningeal artery b) Forward displacement of the middle cerebral artery The pericallosal artery is displaced 1 cm from left to right c) The internal cerebral vein is displaced 7 mm from left to right

difficulty Left carotid angiography (Fig 1) demonstrated a left parietal mass lesion At operation a meningioma measuring approximately 5 cm×5 cm was removed from the posterior parietal area

Case 2 A 49 year old man was admitted for investigation of seizures of eight weeks duration Initially he was investigated at another institution where angiography and ventriculography were reported as normal He was discharged and readmitted to this institution with recurrence of his seizure disorder Neurologic examination revealed a left hemiparesis with minimal hyperreflexia The cerebrospinal fluid protein was elevated to 90 mg % Right carotid angiography (Fig 2) demonstrated a space occupying lesion in the parieto occipital region At operation the bulk of the tumor mass was found about 1 cm posterior to the burr hole Histologic investigation showed a pleomorphic anaplastic malignant neoplasm resembling a metastatic carcinoma The primary source was not found and the patient was discharged

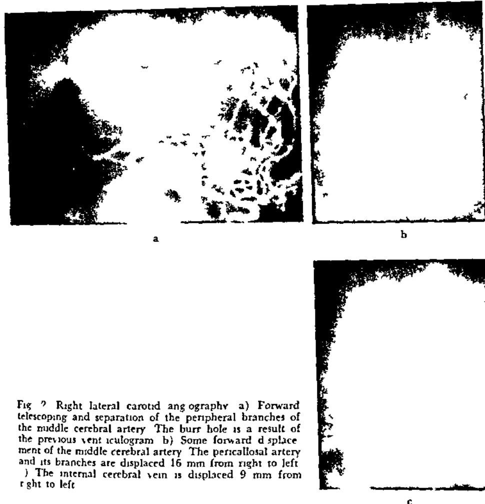


Fig ? Right lateral carotid ang ography a) Forward telescoping and separation of the peripheral branches of the middle cerebral artery The burr hole is a result of the previous vent iculogram b) Some forward d splace ment of the middle cerebral artery The pericallosal artery and its branches are displaced 16 mm from right to left) The internal cerebral vein is displaced 9 mm from r ght to left

Discussion

In both cases with tumours present in the posterior parietal regions the meas ured displacements of the pericallosal artery exceeded those of the internal cere bral vein Different factors could singly or together account for these seemingly paradoxical appearances Displacements of the internal cerebral vein are gener ally measured on the anteroposterior phlebogram at the venous angle Displace ments of the pericallosal artery are measured at the point of greatest shift which in posteriorly situated tumors is immediately anterior to the point where the



Fig 3 The posterior arrow marks the point where the pericallosal arteries displacements are measured and the anterior arrow the venous angle where venous displacements are measured

artery passes under the free edge of the falx Anatomically (Fig 3) this point is posterior to the venous angle and would therefore come under more direct pressure effects from a posterior tumor and could therefore be shifted to a greater degree

The internal cerebral vein is a short structure hinged posteriorly at its attachment to the great vein of Galen and extending forwards 3 to 4 cm whereas the pericallosal artery is a much longer vessel and accordingly has greater laxity Limitations on its lateral movement would therefore be less than those imposed on the internal cerebral vein With large masses, the distance the internal cerebral vein could shift would be limited to a certain maximum amount, and any further shift of midline structures would be manifested by continuing shift of the pericallosal artery and not of the internal cerebral vein

SUMMARY

Tumor masses situated behind the bi parietal plane can on occasions cause greater shifts of the pericallosal artery and its immediate branches than of the internal cerebral vein This could be explained by the structural anatomical relationships of the artery and of the vein

ZUSAMMENFASSUNG

Tumoren die hinter der Bi Parietalebene liegen konnen zuweilen eine grossere Verschiebung der A pericallosa und ihrer Aste als der Vena cerebralis interna verursachen Dies mag ihre Erklarung in den struktur anatomischen Verhaltnissen zwischen der *Arteria* und der Vena finden

RÉSUMÉ

Des masses tumorales situees en arriere du plan biparietal peuvent dans certains cas deplacer l artere pericalleuse et ses branches immediates plus qu elles ne deplacent la veine cérebrale interne Ceci peut s expliquer par les rapports anatomiques structuraux de cette artere et de cette veine

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SUMMARY

Tumor masses situated behind the bi parietal plane can on occasions cause greater shifts of the pericallosal artery and its immediate branches than of the internal cerebral vein. This could be explained by the structural anatomical relationships of the artery and of the vein.

ZUSAMMENFASSUNG

Tumoren die hinter der Bi Parietalebene liegen können zuweilen eine grössere Verschiebung der A. pericallosa und ihrer Äste als der Vena cerebralis interna verursachen. Dies mag ihre Erklärung in den struktur anatomischen *Verhältnissen zwischen der Arteria* und der Vena finden.



Fig 1 Atherosclerotic ulceration and thrombosis An area of lipoidal degeneration has extended to the inner surface of the atherosclerotic artery and atheromatous material has been released into the lumen to form an ulcer (upper right arrow) Further evacuation of the sublumenal stratum would result in a collar button shaped cavity with overhanging edges Numerous areas of fatty softening are present in the depths of the atheroma away from the lumen (left arrows) A thrombus has formed in the remaining arterial channel on the rough surface of the atheroma (right lower arrow)

Pathology Ulceration of an atherosclerotic plaque constitutes a complication of the basic lesion along with hemorrhage thrombosis and other changes (WHO Report 1958) Ulcerated lesions are commonly found in the aorta and some of its larger branches including the carotid arteries in the neck Moossy (1966c) found it to be the most frequent significant complication of atherosclerosis of the major neck vessels in 204 necropsy examinations that included total dissection of the extracranial carotid and vertebral arteries The ulcerations were found most often at the main cervical carotid bifurcations the points where atherosclerosis of the cerebral circulatory tree has the earliest period of onset — early changes having been described here in the second decade of life (Moossy 1965 1966a)

An atheroma has been defined as an atherosclerotic plaque in which fatty softening predominates (WHO Report 1958) When such softening reaches the lumenal surface of the plaque grumous material may be extruded into the blood stream leaving a cavity or ulcer niche in the atheroma (Fig 1) Subsequently varying amounts of the lipoidal material may be repeatedly released from below the surface of the atheroma through the ostium and in this way, a collar button shaped ulcer may be formed (Fig 1) The excavations may be multiple and vary from microscopic to large size occasionally being larger than one centimeter (Fig 6)

There does not appear to be a direct relationship between the degree of reduction of the arterial lumen produced by connective tissue proliferation and the development of ulceration Instead stenosis results from profuse dense fibrous intimal thickening ulceration is seen more frequently in an atheroma in which

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ATHEROMATOUS ULCERATION IN MAJOR NECK VESSELS AS A CAUSE OF CEREBRAL EMBOLISM

by

ERNEST H WOOD and JAMES W CORRELL

Ulceration of an atheromatous plaque provides the opportunity for an embolic complication through (1) the discharge of grumous lipid material into the vessel lumen and (2) a further roughening of the intimal surface upon which thrombi may form, and subsequently break loose into the blood stream The ability to predict which carotid atheromatous lesions are most likely to produce stroke or blindness through embolization would appear to be of value in clinical management As far as we know, a study of the angiographic findings denoting ulceration in a large series of cases of extracranial carotid atherosclerosis has not been undertaken prior to the work herein reported It is the purpose of this paper to evaluate the importance of ulceration in a group of 160 patients subjected to carotid endarterectomy and to describe angiographic changes that have been found associated with atheromatous carotid ulceration and cerebral embolism

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Fig 3 Cerebral embolus composed of cholesterin The lumen of a small cerebral arterial branch has been occluded by elongated crystals of cholesterol B tween the cholesterol clefts there is an infiltration of phagocytes and fibroblasts indicating beginning organization of the mbolus (Verhoff stain)

small size of the ves els involved (8 to 83 micra) and the presence of adequate collateral circulation in the small areas supplied YATES & HUTCHINSON (1961), in their special report concluded that the extracranial lesions of atherosclerosis are of greater importance in the pathogenesis of cerebral infarcts than primary intracranial arterial lesions

The secondary cerebral vascular occlusions owing to emboli from primary cervical lesions may be of two types First the atheromatous material evacuated into the carotid lumen during the formation of an ulcer may block a cerebral artery (Fig 3) Such emboli are composed chiefly of cholesterol lipid material and lipophages they may fragment and be dispersed after only temporarily blocking a large vessel (Fig 4) When permanent blockage occurs, fibroblasts *infiltrate* between the cholesterol crystals to organize the embolus

Second embolism may result from fragmentation of a thrombus that has developed within a carotid ulcer as noted above In addition mural thrombi may form on a carotid atheroma apart from the site of an ulcer (Fig 1) under such circumstances an opportunity exists for the concomitant metastasis of atheromatous material and fragments of thrombi Any embolus may produce through ischemia a tertiary cerebral lesion causing pathologic changes in anatomy, such as infarction, or physiology such as seizures or both

Clinical correlation During the last decade *ophthalmologic* observations have led to a clearer understanding of the *relationship* of primary carotid lesions to secondary embolic phenomena FISHER (1959) described a patient with transient monocular blindness *which he* related to atherosclerotic disease of the ipsilateral cervical carotid artery In a study of 235 patients with atherosclerotic disease of the extracranial carotid systems HOLLENHORST *(1961)* found that



Fig. 2. Surgical specimen removed by endarterectomy. A 3 cm long atheroma from the cervical carotid arterial bifurcation has been opened along its anterior wall with the common carotid portion on the reader's right. Above on the left a thick atheroma has narrowed the proximal internal carotid artery to 10 % of its normal caliber. Near the origin of the internal vessel the 4 mm diameter circular mouth of an ulcer is shown (upper arrow). The thin base of the large cavity beyond is transilluminated. The orifice leading to the external carotid artery has not been opened (lower arrow).

fatty softening is most evident. In general (see "Radiologic findings") when ulceration was present the degree of arterial stenosis tended to be less, suggesting that in these patients events leading to surgical intervention occurred earlier.

In addition to thickening of the tunica intima, thinning of the tunica media is an important feature of atherosclerosis (Fig. 1). The development of an atheroma in the intima is usually associated with underlying atrophy of the muscular and elastic fibers of the media which, in some cases, may be marked. Atheromatous lesions can encroach not only on a circulatory channel but, through a loss of muscular and elastic tissue, may produce a loss of mural support. Deep ulcers in heavy plaques frequently extend almost to the tunica adventitia.

Chiari (1906) described ulceration of the extracranial carotid arteries and suggested a relationship of the lesions to encephalomalacia caused by the detachment of thrombotic fragments that occluded intracranial arterial branches. The importance, and frequent occurrence, of embolism from arterial ulcers did not receive adequate emphasis until the reports of Flory (1945), followed by Meyer (1947), Gore & Collins (1960) and others as summarized more recently by Sturgill & Netsky (1963). In a pathologic study of cerebral infarcts occurring shortly before death Moossy (1966b) found that in 55 % of patients a recent cerebral thrombosis accounted for the lesion; in 45 % the extracranial carotid arteries were indicted. In the cases with old infarcts, indicating past occlusions that the patients had survived, most of the thrombi were in the extracranial carotid arteries (Moossy 1966c). In support of the conclusions above, Winter (1957) found that many atheromatous cerebral emboli occurred without producing recognizable infarcts — probably because of the

One of the early *neurologic* correlations of extracranial carotid disease and vascular lesions of the brain was made by HUNT (1914) He alluded to embolism as a possible cause of infarction and encephalomalacia he also urged a consideration of extracranial carotid atherosclerosis in the differential diagnosis of cerebral lesions of vascular origin Only after the advent of percutaneous angiographic techniques to demonstrate during life all of the major arteries of the neck was rapid progress made

In a clinicopathologic correlative study of carotid occlusion FISHER (1954) found that mural thrombotic deposits upon atherosclerotic ulcerations at the cervical carotid bifurcation occur frequently especially if smaller microscopic changes are included He described four cases of cerebral embolic complications resulting from the fragmentation of mural thrombi deposited in ulcerated atheromas

GUNNING et coll (1964) reviewed the clinical and pathologic reports on the relationship between extracranial carotid atherosclerosis and intracranial complications during the decade intervening and described 16 cases of their own that had been studied in detail The authors concluded that in many instances embolism afforded a more satisfactory explanation of transient ischemic attacks than the theory of recurrent hemodynamic crises Embolism was suspected because (1) attacks were of sudden onset and lasted only a short time (2) ischemia involved a focal area and not always the same area (3) when both ocular and cerebral symptoms occurred they often did not occur simultaneously (4) transient ischemic attacks ceased when a diseased carotid artery became fully occluded

Cervical carotid atherosclerosis concluded FISHER (1954) is a common disorder the pathologic picture is complex and the changes in the brain depend on many factors Many puzzling cases of cerebrovascular disease could be solved by routine examination of the extracranial carotid arteries at necropsy (FISHER) The material presented below indicates how radiologic and surgical procedures can provide answers during life and help span deficiencies in clinicopathologic correlation

Material and findings

The report is based on a series of 160 endarterectomies performed at the Neurological Institute of New York in patients suffering from cerebral ischemia Detailed information concerning each case has been recorded by a system allowing data recall Clinical radiologic and laboratory findings have been correlated prospectively and also retrospectively with observations at operation and with changes found in the pathologic specimens Particular attention has been given to the angiographic features of the carotid arterial lesions with the ob-

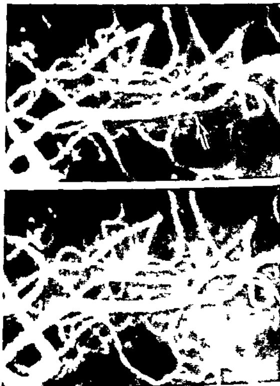


Fig 4 Incomplete embolic occlusion of the angular artery In the upper angiogram an embolus has produced a filling defect at an arterial fork (arrow) Some contrast material flows in a thin stream around each side of the embolus The lower view obtained 30 minutes after the first reveals that the lesion has disappeared and the arterial channels restored to normal size

11 % had from a single to several dozen yellow to orange bright plaques situated at various bifurcations of retinal arterioles (Fig 5) Only occasionally did a bright plaque occlude an arteriole, instead it was found that the embolic plaque often fragmented, lodging successively at smaller distal bifurcations finally disappearing from the retinal circulation

In a few instances HOLLENHORST found that retinal vessels were completely occluded but, in these cases the plaques were not brightly colored but creamy white in appearance the white bodies did not break up but usually remained in the place first seen The author concluded that the bright bodies were emboli of material from an atheroma, chiefly cholesterol, and that the white bodies were clumps of fibrin and platelets

Through histopathologic and biochemical studies in a well documented case of atheromatous embolism, DAVID et coll (1963) showed that the retinal emboli were composed of cholesterol and cholesterol esters All of the patients studied by HOLLENHORST who had angiographies performed, had demonstrable lesions of the appropriate cervical carotid system, all of the remainder (not studied by angiography) had symptoms and signs of cervical carotid disease Similar observations have been made by RUSSELL (1961), MCBRIEN et coll (1963) and BALL (1966)



Fig 6 Large atheromatous ulcer An unusually large ulcer crater measuring 15 mm in length and 7 mm depth projects backward from the distal common carotid artery near its bifurcation A distinct neck and overhanging edges are shown The rostral and caudal margins of the cavity are irregular owing to mural thrombi Atherosclerotic irregularities are seen in profile and en face in the internal and common carotid vessels a moderate degree of stenosis is present just below the bifurcation The flat ulcer base appears to extend outward beyond a line drawn to connect the posterior walls of the common and internal carotid arteries If however the thickness of the vessel wall is added to the width of the intralumenal contrast material the ulcer does not project beyond a second line drawn The crater was entirely within the atheromatous lesion of the intima which extended into the mural area normally occupied by the muscular and elastic tissues of the tunica media

ulcers were demonstrated by angiography and confirmed at operation or by pathologic examination of the surgical specimens In a very few additional cases a small ulcer was found at operation that could not be recognized in the angiograms but often it was necessary to use the dissecting microscope to identify these lesions It is conceivable that an ulcer could be fully filled with thrombus and not be visible at the time of angiography but this would appear to be a rare occurrence ince no examples were found in the series

All of the ulcers were located within atheromatous lesions at the cervical carotid bifurcation none of the craters being situated more than 2 5 cm from the fork of the arterial division (Fig 2) Ulceration was more common in the larger atheromas measuring 3 to 4 cm in length and was seldom found in small plaques involving short arterial segments More often than not the craters were near the mid portion of an atheroma although it was not unusual to find such lesions in the proximal or distal 1 cm of a plaque The common and internal carotid arteries were involved with almost equal frequency with many lesions being at the level of the bifurcation itself Ulceration in the external carotid artery was rarely encountered It is of interest that in the great majority of cases the ulceration was found along the posterior wall

In most cases only one macroscopic area of ulceration occurred In the minority multiple craters were present in the same vessel (Fig 7) At the same time many patients had bilateral ulcerations one third of the cases falling into this category Almost all patients who had ulceration on one side also had vary



Fig 5 Retinal photograph of a cholesterol embolus A bright body has lodged at a distal bifurcation of the superior temporal artery of the retina A complete obstruction was not produced but intravascular agglutination owing to slow flow was observed in branches distal to the lesion

jective of developing criteria for the pre operative recognition of the complication of ulceration in atheromas

Simultaneous biplane angiography was carried out in every case investigated at the Neurological Institute This approach affords the greatest opportunity to demonstrate any significant depression in the intima, or crater, either in profile or en face Every film was studied to determine whether or not a defect in the outline of an atheroma was present and, if so a tracing was made on translucent film The common features of the depressions were tabulated to establish the diagnostic configurations of ulcers The percentage stenosis produced by the atheromatous plaques was also noted

The angiograms were scrutinized for evidence of embolization as manifested by blockage of a distal artery The probability of finding radiologic evidence of such a secondary lesion with current techniques is remote, nevertheless, it may occasionally be seen (Fig 4)

In addition, ophthalmoscopic evidence of vascular occlusion was sought in patients with amaurosis fugax or other forms of amblyopia (Fig 5) Retinal changes were correlated with clinical symptoms and radiologic findings Recently all patients have had studies by thermography, Doppler ultrasonic blood flow analysis and dynamic gamma emission radiography, although it appears unlikely that any specific finding, using these media, could be ascribed to ulceration

Radiologic findings The incidence of ulceration as a complication of atherosclerosis among the group of patients studied was 54 % In 87 of the 160 cases,



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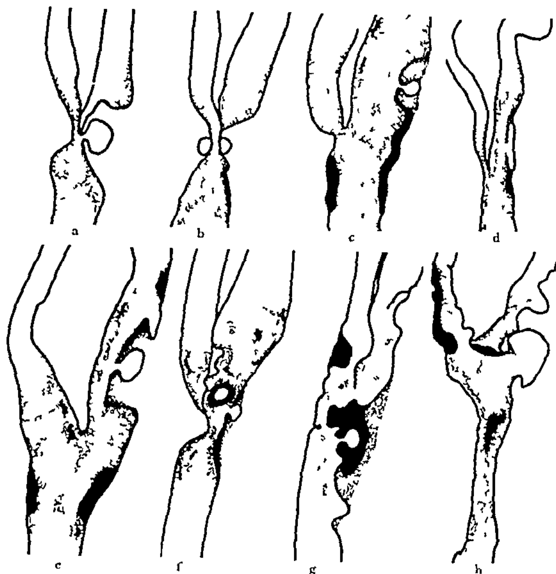


Fig. 7. Tracings of typical atheromatous ulcers made from angiograms of the various cases to determine diagnostic features of ulceration, the sequence of figures being representative of the group. a) Ulcer seen in profile projecting into an atheroma from a markedly stenotic carotid bifurcation. b) En face view of the same lesion as depicted in (a). The right angle view projects the crater as straddling the stenotic area. c) Small ulcer projecting into an atheroma in a vessel only locally narrowed by the plaque. d) Long shallow ulcer with overhanging edges in an internal carotid artery narrowed approximately 50% by stenosis. e) Segmental narrowing of the internal carotid artery by a thick atheroma. A crater with a distinct neck projects deeply into the central portion of the atheroma but the base does not extend beyond the projected line of the arterial wall. f) Two ulcers are present at a markedly deformed carotid bifurcation. The distal ulcer is seen en face, viewed through its mouth; the margins of the ostium are demarkated by a halo caused by the overhanging edges. The lower ulcer is seen in profile. g) Right angle view of the lesion shown in (f). Only the distal ulcer is seen and now in profile; the neck, overhanging edges and central projection of the crater into a larger atheroma are evident and can be correlated with the appearance in (f). h) This is not an ulcer but a post-stenotic diverticulum. The projection from the internal carotid artery shown in profile extends outward well beyond the line of the vessel wall.

Atheromatous ulcers were found to be intramural in all of the cases in the group

ing degrees of stenosis or atheromatous plaque formation on the opposite side Among the patients with unilateral ulceration, involvement was equal in frequency on the right and on the left

The areas of ulceration varied in size from 2 mm to 1 5 cm greatest diameter It was difficult to recognize with certainty from the angiograms ulcers that were smaller than 2 mm although in a few instances the presence of smaller lesions was suspected In two patients an atheromatous ulcer was demonstrated in the neck and a secondary embolic lesion demonstrated distally in an appropriate intracranial vessel, one was at the internal carotid artery bifurcation and an other in a large middle cerebral arterial branch (Fig 4)

Angiographic diagnosis is contingent upon the demonstration of contrast material projecting into an atheroma which, in turn projects into the vascular lumen as a filling defect in the main stream of contrast material outlining an artery The greatest information concerning atheromatous ulceration is gained when the lesion is seen in profile (Fig 6) When biplane angiography is used, four segments of the arterial wall are viewed tangentially and simultaneously, greatly enhancing the probability of noting any outpocketing of contrast material beyond the main column Useful radiologic information may also be obtained with a projection en face

In profile a typical atheromatous ulcer is characterized angiographically as a hallow cavity communicating by a distinct (often narrow) neck with the patent channel of the artery Larger ulcers have a wide base with overhanging edges and a mouth relatively central to the excavation The crater is situated near the mid portion of an atheromatous lesion in many instances and near the most elevated area of the thickened intima (Fig 7) In some cases the cavity may be very large occasionally it is deep rather than long and shallow Often the base of the ulcer is smooth but at other times it is irregular suggesting incomplete evacuation of an atheroma or the presence of thrombi (Fig 6) Small ulcers may appear as a niche and be difficult to differentiate from the multiple small depressions between the nodular elevations of the surface of an atheroma.

In an image en face it is often possible to see again the ostium connecting the arterial channel and the ulcer crater Surrounding the circular mouth of the ulcer it is sometimes possible to observe a slightly less dense ring or halo caused by the presence of contrast material in the cavity of the lesion beneath the over hanging edges (Fig 7) The en face projection may show the diameter of the ulcer base clearly when the area of excavation extends beyond the main column of contrast material in a markedly stenotic artery In cases where there are well developed atherosclerotic plaques without marked stenosis the en face view of the plaque may reveal multiple small nodular defects that do not extend prominently into the lumen but are large enough to cause a stippled appearance owing

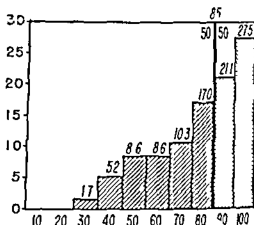


Fig 8 Degrees of stenosis in patients without ulceration *Varying percentages of arterial narrowing are shown along the abscissa* the percentage of cases falling into each group is shown *along the ordinate* The median figure was 85 % narrowing for the 73 patients requiring endarterectomy who had uncomplicated stenosis

to a reduction in density of the column of contrast material Marginal irregularity also may be produced by the process Under such circumstances the depressions between the nodules could be mistaken for small ulcers, as in the profile view, but the lack of roundness does not favor a true crater Correlation with the right angle projection aids in clarifying the significance of the appearance

One of the most characteristic findings of ulceration is that the cavity is contained within the atheroma Although excavation may occur in a collar button fashion for a considerable length and width of the vessel, the base of the ulcer does not extend outward beyond the projected normal line of the arterial wall While there is marked thinning of the media owing to atrophy of the muscular coat and the elastic tissue fibers, the tunica media is not directly involved in the ulceration At the time of endarterectomy it is consistently shown that the cavity is all within the thickened intima, when an atheroma is dissected away along the normal line of cleavage between the diseased intima and the atrophic media, the base of the ulcer is included in the excised atheroma In many instances only a thin layer of tissue covers the base of the cavity which readily permits transillumination by light (Fig 2)

In the angiogram showing an ulcer in full profile, the base of the crater may appear to extend beyond a line drawn to connect the contrast outline of the inner wall of uninvolved segments of the artery proximal and distal to the atheroma *If allowance is made for the normal thickness of the tunica media* and adventitia and, when applicable, if further allowance is made for the normal slight dilatation *at the region of the carotid sinus*, it becomes evident that the base of the ulcer is within this extrapolated line of the vessel wall The outward growth of the intima *during atherosclerotic thickening at the expense* of the muscular coat allows the base of the ulcer to be projected almost to the plane of the adventitia and still be *contained within the diseased intima*

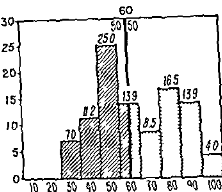


Fig 9 Degrees of stenosis in patients with atheromatous ulceration As in fig 8 the percentage of vascular narrowing is along the abcissa and the percentage of cases in each decimal is on the ordinate The median was 60 narrowing among the 87 patients who had ulceration as a complication of carotid atherosclerosis Comparison of the two bar graphs reveals that in the average case of atherosclerotic ulceration the patient was seen when there was 30 e less stenosis of the artery b cause symptoms were produced by emboli

In one case (not included in the series because there was no ulcer) a cavity with a round base extended outward well beyond any imaginable extension of the vessel wall at the time of angiography (Fig 7) When the vessel was examined at necropsy it was found that there was (1) stenosis of the distal few centimeters of the common carotid artery (2) narrowing of the external carotid artery by extension of a large atherosclerotic plaque into the vessel (3) an atheromatous ring near the origin of the internal carotid artery that partially occluded the lumen (4) a short segment of arterial wall just distal to the ring like narrowing essentially free of atherosclerotic disease and (5) a true outward bulge of the vessel at this point resulting in a diverticulum like projection On histologic examination there was no evidence of ulceration the elastic and muscular tissues of the tunica media were preserved Apparently the preservation of elasticity allowed pulsatile expansion of the vessel wall in the area and since flexibility was not present proximally a post stenotic pressure dilatation was the result

The degree of stenosis of the carotid lumen for all of the patients having endarterectomies with and without ulceration have been tabulated (Figs 8 and 9) Although the ulcerations occurred in relatively thick atheromas in the majority of instances the degree of stenosis varied greatly In some cases ulcers complicated already markedly stenotic carotid arteries (Fig 7) At other times ulcers occurred in ectatic vessels in which atheromas did not narrow the channel significantly In the average case of stenosis without ulceration the narrowing of the carotid channel necessary to produce cerebral ischemia was 85 % In the group of patients who had atheromatous ulcers the median was 60 % stenosis The figures indicate that in the case of atherosclerotic ulceration patients are seen when there is 30 % less narrowing of the artery and that half of the patients

had less than 60 % reduction in caliber of the carotid lumen. In 6 patients in the ulcer group there was only 30 % narrowing of the carotid lumen. The findings fit well with other data described above indicating that symptoms are produced by emboli in the patients with ulcers rather than hemodynamic crises, as in the cases with pure atherostenosis.

Surgical findings and treatment. The findings at the time of operation and the subsequent examination of the surgical specimens corroborated, in almost all instances, the radiologic findings described above. Only with very small ulcers measuring less than 2 mm in diameter and depth did pre-operative detection of ulceration by angiography fail.

The indications for surgical treatment in the overall group were, in the final analysis, based on a clinical assessment of the cerebral ischemia; it is not within the scope of this paper to discuss the numerous considerations affecting the choice of treatment. The radiologic finding of a definite ulcer crater in an atheroma, however, brought strong consideration of surgical treatment in patients with transient ischemic attacks, even though the degree of carotid stenosis was mild and well below the level that usually produces cerebrovascular insufficiency. EHRENFELD et coll. (1966) considered any form of cervical carotid atherosclerosis found in patients with transient monocular blindness to be an indication for endarterectomy.

The technique of surgical treatment has been described in another paper presented at the VIII Symposium Neuroradiologicum (WOOD et coll.). It is noteworthy, however, that the technique employs a bypass procedure from the common carotid to the internal carotid artery, shunting the blood flow around the atheromatous lesion during operative removal. Microsurgical techniques, as described by SCHEIBERT (1959), JACOBSON et coll. (1962) and CHOU (1963) were not used in the current series to treat the secondary intracranial lesions originating in the ulcerated cervical carotid atheromas.

The complications of operative treatment have been extremely low and quite acceptable, as also described in the paper noted above (WOOD et coll.). In the present study the results of endarterectomy for atheromatous ulceration may be stated briefly as 'curative'. With the eradication of the source of emboli and the restoration of good blood flow through a stenotic segment no patient subsequently had either symptoms or signs related to the treated artery. Subsequent difficulties, when occurring, were not due to new emboli, or reduced blood flow, at the old site. In no case was death caused by a recurrence of disease at the site of reconstruction of the atherosclerotic artery. In a control group the patients did not exhibit corresponding improvement or enjoy freedom from new symptoms over periods of extended observation.

Discussion

From the growing literature there no longer appears to be any reason to doubt that a cause and effect relationship exists between extracranial carotid atheromatous ulceration and cerebral embolic disease. The present work supports the suggestions of pathologists and earlier clinical investigators that a high percentage of patients have cerebral ischemia on the basis of embolic events. Most important, the present report describes a method of detecting individuals preoperatively who have ulceration as a complication of atherosclerosis: criteria have been developed that make it possible to diagnose ulceration radiologically with a high degree of confidence.

A number of clinical features not previously emphasized pertained to the group of patients with ulceration as opposed to those with uncomplicated atheromatous stenosis. Generally the patients came for medical treatment after fewer transient ischemic attacks than patients with severe stenosis and no ulceration. A surprising number of patients with ulcerated lesions reported only a single attack; the majority with such symptoms had less than ten ischemic episodes. A significant number of patients with atheromatous ulceration experienced convulsive seizures. The embolic phenomena apparently were more alarming to the patients than those resulting from hemodynamic crises occurring in uncomplicated atherosclerotic stenosis. As in the smaller group of patients studied by GUNNING et coll. (1964) systemic changes (such as lowering of the blood pressure or anemia) and hemodynamic crises (as produced by fainting, change in posture, hemorrhage, or cardiac arrhythmias) did not play a role in the precipitation of strokes as is often the case in carotid stenosis without embolism.

The importance of local trauma to the cervical carotid bifurcation as a precipitating factor in embolism was emphasized by HOLLENHORST (1961). Even minor trauma to the neck, as reported by WITMER & SCHMID (1958), GORE & COLLINS (1960), can be important. External trauma to the neck appeared to play a role in the production of cerebral embolism in eleven patients (approximately one-eighth) of the present group studied.

Consideration for the importance of local injury was given in the management of patients after admission to the hospital. Steps were taken to reduce to a minimum the possibility of inducing further embolism during diagnostic studies or operative treatment. COGAN et coll. (1964) described embolism owing to carotid angiography. HOLLENHORST (1961) and SHILLITO & ROCKETT (1963) and others have described embolism as a complication of carotid endarterectomy.

In order to avoid local trauma by needle puncture near the cervical carotid bifurcation, angiography was routinely performed by means of an aortic arch catheter in cases of cerebrovascular disease studied during recent years. The

procedure has been monitored by means of ophthalmoscopic observation during examinations and through retinal photographs taken before and after the injection of contrast material into the arch of the aorta. Such an indirect and more physiologic means of study has not produced retinal artery embolism in any of the patients examined.

The steps taken to prevent injury at operation include delicate handling of tissues during exposure of the carotid arteries, occlusion of the internal carotid artery when manipulation of the atheroma bearing site is necessary and establishing a bypass around the atheroma before endarterectomy and carotid reconstruction. Postoperative complications owing to further embolism during surgical treatment have not been observed.

SUMMARY

Atherosclerotic ulcers that could have been the source of cerebral emboli were found in 54 % of 160 patients coming to carotid endarterectomy. Identification of an atheromatous ulcer can be made radiologically with a high degree of confidence. Patients with ulcers are seen earlier than those suffering from cerebral ischemia produced by uncomplicated carotid stenosis. Not one of the 87 patients having the source of embolism removed by endarterectomy had subsequent transient ischemic attacks or developed any new symptoms related to the reconstructed artery.

ZUSAMMENFASSUNG

In 160 Patienten, bei denen eine Endarteriektomie der A. carotis durchgeführt wurde, fanden sich in 54 % Ulcera, die vermutlich die Ursache der cerebralen Embolien waren. Eine atheromatöse Ulceration kann radiologisch mit hochgradiger Sicherheit festgestellt werden. Patienten mit Ulcera kommen früher zur Untersuchung als Patienten mit cerebraler Ischämie, die von einer unkomplizierten Stenose der A. carotis hervorgerufen ist. Keiner der 87 Patienten, bei denen die Embolien durch Endarteriektomie entfernt wurden, hatte vorübergehende ischämische Attacken oder entwickelte irgendwelche mit der rekonstruierten Arterie in Verbindung stehende Symptome.

RÉSUMÉ

Sur 160 malades qui ont subi une endartériectomie carotidienne, 54 % avaient des ulcérations athéroscléreuses qui pouvaient être la source d'embolies cérébrales. L'angiographie permet avec une bonne précision de déceler ces ulcérations qui sont une indication d'endartériectomie, quel que soit le degré de la sténose associée. Aucun des 87 malades endartériectomisés n'a eu par la suite d'accident ischémique transitoire ni de nouveaux symptômes en rapport avec la reconstruction artérielle.

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NEURORADIOLOGIC EVALUATION OF RESULTS OF SURGICAL TREATMENT OF EXTRACRANIAL ATHEROSCLEROTIC DISEASE

by

E H Wood J W Correll, Fr K Bochenstein A Reilly and Jan N Safer

In many clinics including our own surgical reconstruction of one or both carotid arteries in the neck is being performed with increasing frequency in the treatment of cerebrovascular insufficiency Thorough clinical and angiographic examinations are disclosing that many patients with cerebral ischemia have significant atherosclerosis at the major cervical carotid bifurcation Experience has shown that reconstructive operations offer (1) relief of cerebral ischemia, (2) prevention of neurologic deficits and (3) improved circulation through collateral channels to portions of the brain not directly supplied by the treated artery This increased use of surgical methods demands a rigid objective evaluation of the results of such treatment While clinical examination remains paramount in assessing the value of therapy several neuroradiologic procedures provide important information concerning carotid endarterectomy, both local changes and some distant effects

It is the purpose of this paper to summarize the results of cervical carotid

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Table 1

Surgical mortality and morbidity in 100 patients (127 operations) during a two-and a half year period (1965—1967)

	Percent of	
	Patients	Operations
Deaths (two)	2	1 6
New neurologic deficit procedure	—	—
Old deficit increased (transient)	1	0 8

special systemic controls) have been developed and are more widely applicable to the variety of atherosclerotic changes that are encountered As a result the number of cases to whom the procedure has been applied has increased slowly, but accelerated appreciably in the last three to four years Our series now totals 170 patients who have undergone 202 endarterectomies 32 bilateral operations have been performed The median age of all patients in the series is 60 years with the usual predominance of men over women The degree of luminal nar rowing for the patients with carotid stenosis was 85 %, a figure that conforms extraordinarily well with the excellent experimental studies of BRICE et coll (1964)

The last 100 patients undergoing endarterectomy have had the benefit of improved techniques operative experience and more rigid criteria for selection of individuals for surgical treatment (Table 1) The presence of severe neurologic deficits and depression of the state of consciousness indicating a sizable area of recent infarction have been found to be most unfavorable factors Among the last 100 patients treated there were many with mild to no neurologic deficit the result has been a gratifying reduction in operative mortality and morbidity

The follow up work effected through the establishment of a stroke study section at the Neurological Institute has made it possible to re-examine patients at regular intervals In all 140 patients have been assessed periodically some for as long as 10 years and only one patient of the group has been lost to follow up The early results of endarterectomy among the last 100 patients treated (when related to the status at the time of operation) reveal two deaths, and in only one instance worsening of the neurologic deficit after operation requiring a change of classification category The clinical improvement after endarterectomy has also been quite acceptable

The lasting effectiveness of successful endarterectomy is evidenced by the fact that no patient surviving the surgical procedure died of recurrence of disease of

endarterectomy at the Neurological Institute of New York and to emphasize the importance of angiography and other neuroradiologic procedures in the early and late postoperative evaluation of these results

Prior investigations Atherosclerotic changes in the major arteries of man have been described in mummies dating back to 1580 B C RUFFER (1911), in an extensive study in Cairo, demonstrated the typical deposits in what appeared to be atheromatous sites Owing to prevailing interest in luetic aneurysms the extent of the lesions, or the cause by arteriosclerosis, was not appreciated until MORGAGNI (1761) described atheromas as a probable 'hindrance to blood flow BICHAT (1801) carefully studied the intima of the vessels HODGSON (1815) and others in London, described atheromas and recognized the value of collateral circulation The term arteriosclerosis may have been first used by LOBSTEIN Professor of Pathology at Strasbourg (1829—1833)

In the 20th century, interest shifted to the production of experimental atherosclerosis in animals The monograph of ANITSCHKOW & CHALATOW (1913) on cholesterol feeding of rabbits aroused keen interest in the human ingestion of cholesterol and the development of arterial disease which has not been settled even today

The relationship between occlusive atheromas of the extracranial arteries and cerebral lesions became apparent to several observers towards the middle of the 19th century COOPER (1836), who reported an account of the first successful operation performed on the common carotid artery for aneurysm described a case of bilateral occlusion of the carotid artery with survival of the patient He reported also on the effects on the cortex and brain stem in animals with carotid and vertebral ligations CHIARI (1906) reported a surprisingly high incidence of severe stenosis or occlusion of the internal carotid arteries by means of necropsy that included neck dissection HUNT (1914) appreciated that the majority of extracranial carotid atheromas causing cerebral lesions still were unrecognized clinically and urged careful neck palpation and auscultation in physical examinations More recently post mortem angiography (STEIN & SVARE 1963, SVARE et coll 1964) and the routine but meticulous neck dissections at necropsy carried out by MOOSSY (1966) have given a better insight into the incidence of extracranial carotid atherosclerosis, the true causal relationship of such carotid lesions to the development of cerebral symptoms except in the typical case still defies clear understanding

Material EASTCOTT and co-workers (1954) are usually credited with carrying out the first successful surgical procedure for cervical carotid stenosis, a segmental resection of an elongated atherosclerotic vessel with end to end anastomosis Since this time, other, generally safer, techniques (not requiring hypothermia or other



Fig 1 Postoperative angiograms of the cervical carotid bifurcation a) The carotid reconstruction has consisted of simple endarterectomy Along the line of dissection of the atheroma from the vessel a cuff like demarcation is evident the absolute enlargement of the lumen at the resection site results from atrophy of the media associated with an atherosclerotic plaque If a saphenous vein graft is inserted between the cut edges of the vessel (b) the resulting lumen may be more than twice the normal (original) size

out soon after the operation Therefore most postoperative studies have been obtained 8 to 10 days after surgery

At this time clinical interest is centered chiefly on the presence or absence of full patency at the site of carotid reconstruction Among the last 100 patients with stenosis undergoing endarterectomy full patency was established and maintained in all but three It is of interest that in two of these patients postoperative improvement was felt to indicate that the artery was open but routine postoperative arteriography demonstrated complete occlusion The third patient did show transient worsening which seemed related to occlusion of the operated artery In a few additional instances where a completely occluded internal carotid was felt to have been opened at the time of operation the postoperative arteriogram demonstrated re-occlusion

At the same time that the operative site is evaluated serialographic study of the cerebral vessels may be carried out for comparison with pre-operative examinations For such quantitative studies of regional cerebral circulation we have used the densitometric film analysis technique devised by HILAL (1966)

At the site of carotid reconstruction the arterial lumen is larger than normal even when a simple endarterectomy is performed without the insertion of a vein graft The intimal changes of marked fibrous thickening are associated with thinning of the tunica media owing to atrophy of the muscular layers and degeneration of the elastic fibers Therefore when the intimal atheroma is dissected from the vessel wall not only is the original lumen restored but the diameter is increased further to the extent that the medial thickness is diminished At postoperative angiography there is often a sharp cuff like line of demarcation be

the reconstructed carotid artery If the actual deaths are extended to a percentage basis, 56 % died of cardiac disease, 11 % had cerebrovascular accidents involving systems other than the one operated, and 33 % succumbed to complications of the original cerebrovascular accident that were not related to the reconstructive surgery, such as bronchopneumonia

The results of endarterectomy as related to the neurologic deficit present at the time of operation have been recorded for the last 100 patients as follows (I) patients who had symptoms of transient ischemic attacks without neurologic findings numbered 32, and all patients had complete recovery (no further symptoms 100 % cure) following operation, (II) of 54 patients who had mild to moderate neurologic deficits, 41 were improved by endarterectomy, 12 were unimproved and one died, (III) if the categories are considered together, it is found that of the 86 patients having endarterectomy who had no deficit (or only mild to moderate deficit) 83 % were improved, 12 patients were unimproved and one died, a failure rate of 17 %, (IV) of 14 patients with severe neurologic deficits at the time of operation, only one improved, and one died, a failure rate of 92 %

Treatment

The surgical procedure used to re establish patency of the carotid artery has been an endarterectomy with or without patch graft After isolation of the carotid bifurcation, a longitudinal incision is made extending from the common carotid artery to the internal carotid, throughout the full length of atherosclerotic involvement An internal shunt is then established using a polyethylene tube extending from the common carotid proximal to the incision to the internal carotid distally (This renders the operative field bloodless and maintains cerebral blood flow) The areas involved are remarkably constant the distal few centimeters of the common carotid, the proximal few centimeters of the internal carotid and to a lesser extent of the external carotid artery being narrowed in the vast majority of patients

Using a dissector and forceps the atheroma is lifted away from the uninvolved outer layers of the vessel A line of cleavage is readily established between the grossly thickened atherosclerotic internal coat and the atrophic medial wall of the artery After separation of the atheroma from the vessel wall, the remaining medial and adventitial arterial layers are approximated along the line of incision At times, a vein graft (usually saphenous or external jugular) has been sutured to the edges of the incision, assuring maximal widening of the artery in the operated area In most cases, the use of a patch graft has proved to be unnecessary

Postoperative angiography is performed in as many patients as possible (Fig 1) This has been found to be most readily acceptable to the patient if carried

Table 2

Results of pre and post-operative thermography (correct 95 %, incorrect 5 %)

Per cent of patients	Operative procedure	
	Pre	Post
59	+	−
12	+	+
29	−	−

WOOD (1964) described the use of thermography in the diagnosis of extracranial carotid stenosis and occlusion Since that time we have examined many hundreds of additional cases and our observations have been validated by the work of AUSTIN (1965), TOOLE (1965) WALLACE & WALLACE (1968) and numerous others and the technique has become one of the several more valuable procedures for the detection of preclinical atherosclerotic stenosis In an extension of our original work it has been established that an area of supraorbital coolness is found over the terminal cutaneous branches of the internal carotid artery, through its ophthalmic division in 90 % of patients with more than 60 % stenosis of the cervical internal carotid artery (WOOD 1965, WOOD & HILL 1966)

Equipment has now been developed that is especially suitable for the diagnosis of extracranial carotid insufficiency In America the thermacorder is a flexible mobile device that travels pendulum fashion in an arc back and forth across the supraorbital or orbital portions of the face or any other area. The temperature of the flat surface of the forehead which forms the cord of the arc is plotted by a high speed recorder A graph is produced that is linear and life size and the automatic repetition of the thermal recorder permits the conducting of physiologic or pharmacologic experiments in which the analysis of temperature changes during a short or long period of time is basic

The thermovision device developed in Sweden is also in use in our clinic (FIG 2) This apparatus has the advantage of an instantaneous television like display on a monitor mounted on the face of the control panel Added flexibility is gained by having the machine in two parts (1) the heat collecting mirror unit that may be carried into a patient's room into an angiographic room or an operating suite and which is connected by a long cable to (2) the control panel and monitor A polaroid film record is made directly from the monitor The instantaneous display feature permits rapid examination the study of uncooperative patients and the conducting of physiologic tests.



Fig. 2. Thermovision in use. The heat collecting mirror unit (on the left) is directed toward the patient. The collector is connected by a cable to the amplifier and control panel where a photograph is made of the electronic display of the patient's heat emission image.

tween the proximal and distal vessel and the segment enlarged by endarterectomy, which in time becomes less abrupt (Fig. 1).

When a venous patch graft is used, the lumen at the site of arterial reconstruction is enlarged even further. At angiography the site of grafting has a smoothly lobulated configuration and approaches a fusiform aneurysmal appearance. Pulsation in the neck may be clearly visible and palpation may reveal an alarming outward thrust over the operative site. Yet, in our experience, there has been no case of early breakdown at the operative site, or of later development of an aneurysm. Two patients have had the operated area explored by others because of a presumptive diagnosis of aneurysm but the diagnosis has not been verified. DE BAKEY et coll. (1961) and MURPHEY & MACCUBIN (1966), each group with large series of endarterectomies, had no patients develop a postoperative aneurysm, nor did HEYMAN et coll. (1967) or WHISNANT et coll. (1963) report such a change.

Newer technique. More recently, attention has been turned to the evaluation of substitutes for cerebral angiography that are innocuous, yet dependable. It is particularly important to have such a technique available for postoperative examination because angiography is undesirable, even if not physically dangerous, as a means of repeatedly studying the cerebral circulation at regular postoperative intervals. Since many of the patients live for a long time after operation a method is needed that is atraumatic, harmless, rapid, and that will give consistently reproducible, and at least semiquantitative, results on repeated follow up clinical assessments.

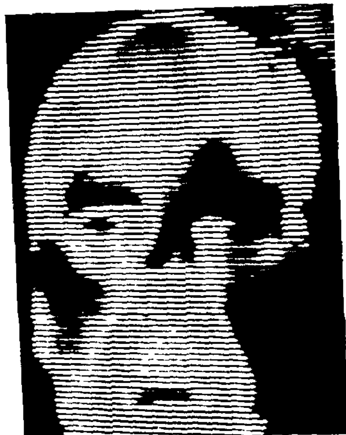


Fig 4 Isothermal display pattern In a patient with left internal carot d arterial insufficiency areas of equal temperature are displayed as similar l ght or dark shades In color thermography a spec fic color may be assigned to narrow bands of equal tem perature and mapping of all of the isothermal values of the area may be recorded on a single film to provide ease of quan titat on.

alse positive thermograms In the last two instances there was bilateral disease ith a steal of external carotid blood from an occluded to a stenotic side through everse flow in the ophthalmic artery (WOOD 1965) In the third group the atients did not have abnormal thermograms before operation because the tenosis was less than 60 % and the thermograms remained normal after opera ion

One of the newer developments in thermography is the introduction of color photography of the television image which provides a wider spectrum for com

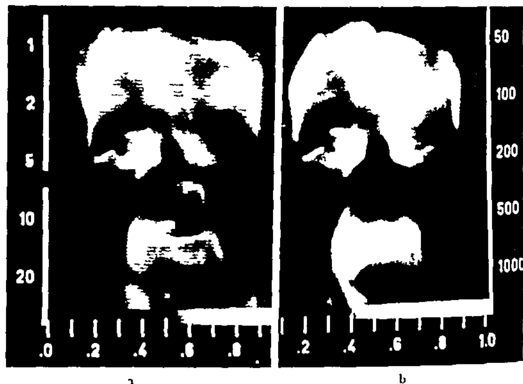


Fig. 3. Bilateral carotid insufficiency. The preoperative thermogram (a) reveals supraorbital cool areas on both sides, suggesting reduced blood flow. After left carotid endarterectomy, the thermogram (b) reveals the medial portion of the forehead to the left of the midline and also the supraorbital region to be white as a result of the warming effect of restored blood flow.

During recent months, thermography has been applied to patients following endarterectomy and we have had the opportunity of examining 91 patients in whom pre- and postoperative angiograms were available for comparison (Table 2). After successful carotid reconstruction, the thermogram reverts to a normal symmetrical pattern if unilateral stenosis or occlusion is present. Occasionally the thermogram will remain abnormal because there is atheromatous disease of the distal carotid artery, usually in the cavernous portion, or an abnormality in the ophthalmic artery itself. The area of supraorbital coolness disappears immediately after operation, as soon as internal carotid flow is restored to normal (Fig. 3). Once reversion has occurred, the thermogram remains normal indefinitely.

Thermography was performed before and after operation, with an accuracy based on postoperative angiography of 95 %. In the majority of patients the expected change from abnormal to normal occurred. The middle group comprises a small number of patients, in whom an abnormal thermogram did not change because occluded vessels could not be opened, and two patients with



Fig 4 Isothermal display pattern In a patient with left internal carotid arterial insufficiency areas of equal temperature are d played as s milar light or dark shades In color thermog aphy a specif c color may be assigned to narrow bands of equal tem perature and mapping of all of the isothermal values of the area may be reco ded on a single film to provide ease of quan titation.

false positive thermograms In the last two instances there was bilateral disease with a steal of external carotid blood from an occluded to a stenotic side through reverse flow in the ophthalmic artery (Wood 196ɔ) In the third group the patients did not have abnormal thermograms before operation because the stenosis was less than 60 ᶜo and the thermograms remained normal after opera tion

One of the newer developments in thermography is the introduction of color photography of the television image which provides a wider spectrum for com

parison of skin temperatures The isothermal feature of the 'thermovision' displays areas of equal temperature as similar light or dark shades (Fig 4) By assigning a color to each temperature difference of 0 5° C an eight color map may be obtained clearly showing the boundaries of warm to cool over a 4° C range The technique allows color mapping of all isothermal values on a single film and through its ease of quantitation it is a more objective procedure than black and white thermography

We have noticed in quite a few of our patients that following endarterectomy, areas of abnormal warmth develop in the medial supraorbital region and at the inner canthus of the eye The change is not the result of sympathectomy, which occurs extremely rarely, and sympathectomy has been notoriously ineffective in allaying the effects of stenosis in the hands of most investigators (SHENKIN et coll 1965) It is thought that the change is most probably a mechanical one, resulting from the surgical reconstruction with channeling of a disproportionate amount of blood from the common carotid into the internal carotid system Postoperative angiography (cf Fig 1) often shows the proximal internal carotid lumen to be between 140 and 170 % of its normal linear width throughout the length of the endarterectomy

In addition to improved thermography equipment Doppler ultrasonography is being used in the postoperative assessment of endarterectomy results Dynamic studies using isotopes promise to be of inestimable value in quantitating pathologic physiologic processes A satisfactory correlation of thermography, ultrasonography and isotope blood flow determinations with angiography, clinical findings and pathologic changes found at operation or in the laboratory has been established

Acknowledgement

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SUMMARY

Clinical improvement after endarterectomy has been satisfactory Among the last 100 patients undergoing endarterectomy the mortality and morbidity rate relating to the operation was 3 % No patient has died of recurrent disease of the reconstructed carotid artery Thermography applied as a part of the routine follow up of operated patients correlated well with the clinical and angiographic examinations Used in conjunction with Doppler ultrasonography and other tests thermography may serve as a satisfactory substitute for postoperative angiography Color photography of the thermographic television image has provided a wide spectrum for comparisons of skin temperature

ZUSAMMENFASSUNG

Klinisch wurde befriedigende Verbesserung nach Endarteriektomie erreicht Bei den letzten 100 Patienten in denen Endarteriektomie vorgenommen wurde war die Mortalitats und Morbiditats Rate 3 % Kein Tod ist auf Grund Rezidiv mit Erkrankung der rekonstruirten Arteria carotis eingetroffen Thermographie als Komplement zu den routinemassigen Nachuntersuchungen der operierten Patienten zeigte gute Korrelation zu den klinischen und angiographischen Untersuchungen Thermographie zusammen mit Doppler Ultrasonographie und anderen Analysen erbietet eine gute Substitution fur postoperative Angiographie und Farbenphotographie des thermographischen Fernsehbildes ein breites Spektrum um Vergleiche der Haupttemperaturen anzustellen

RÉSUMÉ

L amelioration clinique apres endarteriectomie pour atherosclerose de la carotide extra cranienne a été satisfaisante Parmi les derniers 100 malades qui ont subi une endartériectomie le taux de mortalite et de morbidite en rapport avec l opération a ete de 3 % Aucun malade n est mort de recidive de l artere carotide reconstruite La thermographie utilisée pour suivre l evolution post opératoire a donné des resultats en bonne correlation avec ceux des examens cliniques et angiographiques et quand elle est utilisée en conjonction avec l ultrasonographie de Doppler et avec d autres examens peut remplacer de façon satisfaisante l angiographie post operatoire La photographie en couleur de l image thermographique télévisee fournit un large spectre pour comparer la température cutanée

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR DOCENT GABRIEL FIALKOWSKI AND THE DEPARTMENT OF NEUROSURGERY (DIRECTOR PROF JAN BROMOWICZ) THE ARMY MEDICAL ACADEMY LODZ POLAND

NORMAL RELATIONSHIP BETWEEN BASAL VEIN AND POSTERIOR CEREBRAL ARTERY

by

JERZY ZAJGNER

The basal vein and the posterior cerebral artery together with the superior cerebellar artery and the trochlear nerve are contained within the ambient cistern The basal vein arises at the anterior perforated substance passes around the cerebral peduncle and ends in the great cerebral vein it lies almost completely in the cistern which however contains only a part of the posterior cerebral artery The artery divides into the internal occipital artery and the temporo-occipital artery as it crosses the tentorial notch these branches lie supratentorially

The basal vein is generally evident at carotid angiography The posterior cerebral artery however has been outlined in only 23 5 % of cases by ENGESET (1948) in 25 to 30 % by KRAYENBUHL & RICHTER (1952) and in 38 4 % by SALTZMAN (1959) The factors influencing its filling have been discussed in detail by SALTZMAN who has also shown that with compression of the vertebral arteries his percentage could have been increased The simultaneous delineation of these two vessels is possible by the subtraction technique (ZIEDSES DES PLANTES 1961)

Since some intracranial processes may influence the course both of the posterior cerebral artery and the basal vein especially when herniation of the brain is imminent or has occurred (BROMOWICZ 1953 ASAMBUJA, LINDGREN & SJOGREN 1956) an appreciation of the normal angiographic appearances of the posterior cerebral artery and the basal vein is important.

The present paper deals with the relationship between the basal vein and the posterior cerebral artery under normal conditions

One hundred normal cases were selected from a series of 900 carotid angio-

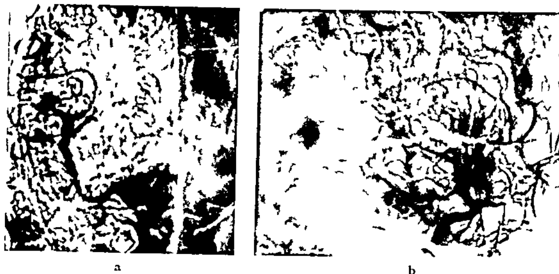


Fig 1 Subtraction views in carotid angiography frontal (a) and lateral (b) obtained by superimposing the positive film of the venous phase upon the negative film of the arterial phase

graphic examinations Only in 26 of these were the basal vein and the posterior cerebral artery clearly visible both in lateral and frontal projections The subtraction images in the two projections were obtained by superimposing the positive film of the venous phase upon the negative film of the arterial phase (Fig 1)

The shape and course of both vessels as well as the relationships between the vessels and their position in relation to the tentorial notch, were evaluated in each film The position of the tentorial notch may be estimated by drawing a line joining the anterior, or posterior clinoid process the bifurcation of the posterior cerebral artery and the origin of the straight sinus (Fig 2)



Fig 2 Probable position of the tentorial notch indicated by a line (broken) joining the anterior clinoid process the bifurcation of the posterior cerebral artery and the origin of the straight sinus

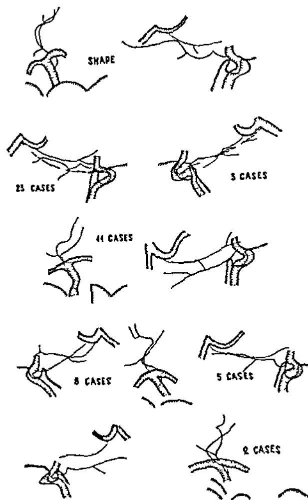


Fig 3 Results of the evaluation of the relationship between *the basal vein posterior* cerebral artery and tentorial notch (broken line)

The results are presented by the schematic drawings in Fig 3 The shape of the basal vein resembles a bow both in lateral and frontal views, the posterior cerebral artery is tortuous in the lateral and arched in the frontal view The basal vein was usually visible supratentorially (23 cases) it sometimes crossed the tentorial notch (3 cases) In 11 cases the basal vein lay medial and cranial to the posterior cerebral artery and in 8 cases both vessels crossed in the posterior part of the ambient cistern They ran close together in 5 cases Sometimes, the vessels were distinctly separated The basal vein lay external to the posterior cerebral artery in only 2 cases

The following conclusions may be drawn The subtraction technique permits a simultaneous demonstration of both the posterior cerebral artery and the basal vein The shape, course and interrelationships of the vessels are variable The basal vein generally lies supratentorially

SUMMARY

The subtraction technique was employed in 26 cases selected from a series of 900 carotid angiographies to demonstrate the basal vein and the posterior cerebral artery The relationship of these vessels to one another and to the tentorial notch is described

ZUSAMMENFASSUNG

In einem Material von 900 Carotisangiographien wurde die Subtraktionsmethode in 26 Fällen angewandt um die Basalvene und die Arteria cerebri posterior darzustellen Die Beziehungen dieser Gefässe zueinander und zu der Incisura tentorii werden diskutiert

RÉSUMÉ

L'auteur a utilisé la technique de soustraction dans 26 cas choisis sur une série de 900 angiographies carotidiennes pour mettre en évidence la veine basale et l'artère cérébrale postérieure Il décrit les rapports de ces vaisseaux entre eux et avec l'incisure de la tente

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CLINIQUE DES MALADIES NERVEUSES ET MENTALES DE L'UNIVERSITÉ DE MILAN,
ITALIE

LA TRIFURCATION CAROTIDIENNE

Incidence et importance clinique

par

DAVID ZERBI et LAURA MIRA

Il est bien connu, depuis de nombreuses années, que la configuration régulière du polygone de Willis n'est pas toujours conforme à la réalité. Des études embryologiques et morphologiques effectuées surtout par des anatomistes (PADGET 1944, ALPERS et coll. 1959, 1963, RIGGS & RUPP 1963) ont démontré du point de vue statistique que 20 % à 30 % seulement, au maximum 50 % des sujets normaux présentent un polygone de Willis « normal ». Cependant, les anomalies de ce cercle anastomotique de la base du cerveau ont bien plus attiré l'attention et n'ont acquis une signification clinique qu'au cours de ces dernières années, lorsque les études anatomopathologiques et surtout radiologiques ont démontré à plusieurs reprises la fréquence et l'importance des occlusions des vaisseaux extracrâniens dans la pathogenèse des ramollissements cérébraux. Alors que l'on a plus souvent reconnu la valeur de la fonction anastomotique et de la compensation du polygone de Willis dans les cas d'occlusion d'un gros vaisseau à destinée encéphalique, au contraire, les études sur les effets pathogéniques des seules variations anatomiques du polygone de Willis dans la distribution et dans l'incidence des ramollissements cérébraux sont encore rares.

La présente recherche, qui est fondée sur l'étude angiographique des variations de la section postérieure du polygone de Willis, se propose justement d'ap-

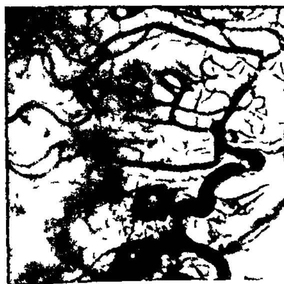


a



b

Fig 1 Angiographie carotidienne droite a) Cliche de profil L artere cerebrale posterieure est vue en meme temps que le siphon carotidien et elle presente un calibre sensiblement uniforme b) Cliche de face L artère cerebrale posterieure est bien demontree mais l artere de l autre cote n etait pas visible



a



b

Fig 2 Angiographie carotidienne gauche a) Cliche de profil Injection complète de l artère cerebrale posterieure ayant comme point de depart le siphon carotidien le trajet initial presentant des caractères infundibulaires b) Cliche de face Opacification tres etendue de l artere cerebrale posterieure du cote gauche



a b

Fig 3 a) Cliche de profil Angiographie de la carotide gauche Derivation de l artere cerebral posterieure à partir du siphon carotidien («trifurcation carotidienne foetale») b) Cliche de face Angiographie de l artere vertebrale Absence de l artère cerebrale posterieure gauche (opacification obtenue par l angiographie de la carotide)

porter une modeste contribution sur un point particulier au probleme complexe et discute de la pathogenese des lesions cerebrovasculaires ischemiques localisees dans la region sylvienne La base de notre etude est constituee par l evaluation des differentes modalites de derivation des arteres cerebrale posterieure et communicante posterieure a partir du siphon carotidien On a utilise pour cela un groupe non selectionne de 779 cas soumis a des examens angiographiques au Service Neuroradiologique de la Clinique Neurologique de l Universite de Milan

Tous les examens angiographiques ont ete faits avec des modalites techniques rigoureusement identiques De l analyse de la presente serie ont ete uniquement exclus les cas techniquement imparfaits

Nous avons examine en detail chaque cliche angiographique du systeme carotidien execute en serie toujours dans les projections classiques de face et de profil uniquement pour ce qui concerne le degre et le type d injection de l artere cerebrale posterieure

Dans 520 cas soit 66 % l injection du moyen de contraste a ete effectuee dans la carotide interne tandis que dans 259 cas soit 34 % elle a ete effectuee dans la carotide primitive Dans les 75 cas ou avait ete egalement executee l angiographie vertebrale l analyse de la morphologie et de la derivation de la cérébrale posterieure a ete etendue aussi aux radiographies correspondantes

Tableau

	Nombre des cas	Trifurcation carotidienne foetale	
		N	%
Néoformations expansives	230	50	21,7
Encéphalopathies diverses (épilepsies, encéphalites régionales)	161	21	13,1
Artériopathies en général (non sylviennes)	270	34	12,6
Artériopathies sylviennes	118	46	38,9
	779	151	19,1

Nous avons pu de cette façon identifier (suivant les critères de SALTZMAN 1959) deux groupes de cas : (1) les uns, avec des images d'injection complète de l'artère cérébrale postérieure rendue visible en même temps que le siphon carotidien et douée d'un calibre sensiblement uniforme (trifurcation carotidienne de type « foetal », selon les anatomistes), et (2) les autres, avec des images de bonne injection de l'artère cérébrale postérieure par l'intermédiaire de l'artère communicante postérieure qui a habituellement un calibre inférieur à celui de l'artère cérébrale postérieure qu'elle rejoint, souvent, avec un angle caractéristique (trifurcation carotidienne de type « transitionnel »).

Ci-dessous sont exposées les données obtenues par examens angiographiques relatives à l'incidence des différents types de dérivation de l'artère cérébrale postérieure.

	Nombre de cas examinés :	779
Trifurcation « foetale »	151 cas	19,4 %
Trifurcation « transitionnelle »	80 cas	10,3 %

A propos des considérations comparatives entre les résultats de la recherche que nous venons de présenter et les données de la littérature exposées à ce sujet, nous nous bornons seulement à souligner la concordance substantielle de l'incidence statistique de nos données avec celle des études analogues effectuées sur la base des recherches anatomiques ou angiographiques les plus importantes (DECKER & HIPP 1958, ENGESET 1948, SALTZMAN 1959).

Nos cas ont été classés en catégories dans un Tableau, en prenant soin d'isoler dans le contexte les cas atteints de troubles ischémiques localisés dans la région sylvienne des sujets vasculopathes.

Nous désirons attirer l'attention sur l'incidence de la trifurcation carotidienne précisément dans les cas atteints de ramollissements sylviens, incidence qui s'est



Fig 4 Angiographie carotidienne droite a) Cliche de profil Trifurcation de type « foetal » b) Cliche de face Angiographie de l artere vertebrale a rendu visible la seule artere cerebrale posterieure gauche

revelee et d une façon significative, beaucoup plus elevee par rapport a notre serie toute entiere et a toute autre categorie de sujets En effet, 38 % des sujets « sylviens » ont une trifurcation carotidienne « foetale » (L elaboration statistique de ces resultats donne en chi =34 184 et un P unilateral<0 00025)

Il faut souligner que dans ce cas nous avons pris en consideration uniquement le type « foetal » de la trifurcation et non le type « transitionnel » Ce critere qui contribue à delimiter un groupe particulier de cas parmi ceux qui sont porteurs d un polygone de Willis presentant une anomalie renforce le caractere fonctionnel de cette condition particuliere dont nous avons l intention d explorer les effets possible sur la circulation cerebrale

En conclusion nous pouvons affirmer encore une fois que l importance des malformations du polygone de Willis dans le domaine de la physiopathologie de la circulation cerebrale est notoirement liee aux alterations de la principale fonction anastomotique du systeme vasculaire de la base de l encephale Toutefois ces anomalies constituent aussi un element qui favorise une ischemie cerebrale possible etant donne qu elles creent par exemple un certain appauvrissement circulatoire a cause de l extention anormale de la zone du cerveau irriguee par un seul vaisseau d origine carotidienne Cette interpretation hypothetique qui confere a une anomalie particuliere du polygone de Willis (la trifurcation

postérieure « foetale ») la valeur d'un facteur favorisant une ischémie au niveau sylvien, à l'aide de mécanismes de détournement, ou bien d'hémométakinésie (FAZIO et coll. 1965), nous semble être renforcée par les conclusions de notre recherche: à savoir que les sujets atteints d'un trouble vasculaire dans la région de l'artère cérébrale moyenne présentent une dérivation totale de l'artère cérébrale postérieure du système carotidien, avec une fréquence plus élevée, et fortement significative par rapport aux sujets non sélectionnés.

RÉSUMÉ

Étude détaillée angiographique et statistique des diverses configurations du polygone de Willis prises dans un échantillonnage non sélectionné de 779 cas. L'anomalie de la « trifurcation carotidienne » dans les cas présentant une lésion vasculaire de la région sylvienne a atteint, du point de vue statistique, des proportions tellement significatives qu'elle a permis une série de considérations et la formulation d'hypothèses pathogéniques basées sur des mécanismes hémodynamiques qui permettent d'expliquer ce type de lésions.

SUMMARY

The circle of Willis in its varying configurations was studied in detail angiographically and statistically in a non selected series of 779 cases. The anomaly termed carotid trifurcation received particular attention in cases of vascular lesions of the sylvian region the frequency of which was of proportions to attain statistical significance. The pathogenesis of this type of lesion is discussed on the basis of hemodynamical considerations.

ZUSAMMENFASSUNG

Die Varianten des Circulus arteriosus cerebri wurden in einem nicht selektiven Material von 779 Fällen eingehend angiographisch und statistisch untersucht. Die Anomalie die als Karotis Trifurkation beschrieben wird, wurde insbesondere in Fällen von vaskulären Läsionen der Sylvius Gegend studiert und die Befunde waren statistisch signifikant. Die Pathogenese dieser Läsion wird auf Basis hemodynamischer Betrachtungen diskutiert.

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ARTERIOVENOUS FISTULAS OF THE MAJOR VESSELS OF THE NECK

by

ALBERT ZILKHA and MANNIE M SCHECHTER

Arteriovenous fistulas of the major vessels of the neck may be divided into those involving the vertebral artery and those involving the carotid vessels The fistulas of the vertebral artery most frequently involve its second portion, next in frequency is its third portion and the least involved is its first portion Fistulas of the carotid vessels may involve the common, the internal or the external carotid arteries

Arteriovenous fistulas of the neck may result from various causes The majority are due to complications of gunshot or stab wounds Recently, a few reports have appeared of arteriovenous fistulas of the vertebral artery following percutaneous vertebral (7, 13, 16, 18, 21, 22, 23) and even percutaneous carotid (5, 20) angiography, where presumably the vertebral artery and the venous plexus have been punctured No cases of carotid artery fistula have been reported following percutaneous puncture of the carotid arteries There are two reasons for this, the first being that the carotid vessels are usually digitally compressed after the procedure has been completed, and closure of the hole in the wall of the artery is assisted by this maneuver, and the second reason is the absence of a periarterial venous plexus, surrounding the carotid artery, comparable to the rich periarterial venous plexus of the vertebral artery Occasionally, blunt trauma

to the neck with or without bony fracture may be the etiologic factor (2 8) Erosion of vessels of the neck by abscess with fistula formation has also been reported Cases congenital (10 26 27) and spontaneous in nature have also been seen Some intentionally induced arteriovenous fistulas have also been published

The various causes of fistulas involving the major vessels of the neck may be summarized as follows (1) traumatic — gunshot, stab wounds blunt trauma to the neck with or without fracture, and percutaneous vertebral and carotid angiography (2) erosion of vessels by abscesses (3) congenital and spontaneous and (4) induced

In traumatic arteriovenous fistulas when the arterial wall is punctured extravasation of blood into a compartment in continuity with the arterial lumen may occur and a false aneurysm is formed If an artery and an adjacent vein are lacerated at the same time the resulting false aneurysmal sac will communicate with both vessels forming an arteriovenous fistula In congenital or spontaneous arteriovenous fistula abnormalities or sudden weakness of the wall of the artery may lead to extravasation of blood and the same process of arteriovenous fistula formation will again be seen

Patients with arteriovenous fistula of the neck usually complain of a noise synchronous with the arterial pulse Auscultation discloses a continuous murmur with systolic accentuation A thrill is felt over the same area Classically compression of the carotid artery will abolish the bruit if the fistula involves this artery and will fail to do so if the fistula involves the vertebral artery This is not always true and some cases of fistulas of the vertebral artery will have their bruit abolished when compression is applied on the carotid vessels Patients with vertebral fistula may have their bruit disappear on turning the head to the side, or on hyperextension of the neck and they usually have symptoms of basilar artery insufficiency Patients with carotid artery fistula may have a decrease in the pulse rate when compression is applied on the carotid vessels (positive Branham's test) These patients may also complain of headaches fainting visual and hearing disturbances and hemiparesis Cardiac decompensation may occur in arteriovenous fistula depending upon the size of the artery involved its situation to the arch of the aorta the size of the fistula, and its duration Because the carotid is larger than the vertebral artery fistulas involving this vessel are more likely to be complicated with hemodynamic effects on the heart than fistulas of the vertebral artery (1 17)

Usually the diagnosis of arteriovenous fistula of the neck is made without difficulty but the involved vessels cannot usually be identified before angiography The most logical approach is to start with cervico-thoracic aortography which will reveal the fistula its site the feeding vessel or vessels and the adequacy of



Fig 1 Case 1 Left vertebral angiograms a) Lateral view Many veins of the cervical vertebral plexus filled in the arterial phase site of fistula not seen b) A p peroral view The fistula (←) at the level of the third cervical vertebra is now clearly seen

the opposite vessels, especially the opposite vertebral artery Should the involved vertebral artery have to be ligated as is often the case in vertebral fistula, the opposite vertebral artery will have to support the circulation to the basilar artery Selective catheterization or direct percutaneous puncture may then follow the cervico-thoracic aortography, to outline precisely the involved vessels In vertebral artery fistula, besides the involved vertebral artery other vessels may feed the fistula, especially the opposite vertebral artery, and also the thyrocervical and the costocervical arteries In some cases of vertebral artery fistula stealing from he anterior circulation may be noted Rapid serial films have to be obtained in order to localize the fistula because the rapid filling of the venous structures may obscure the site of the fistula

Carotid jugular fistulas should be treated by excision of the fistula, with vascular wall reconstruction Either lateral arteriorrhaphy or end to end anasto-

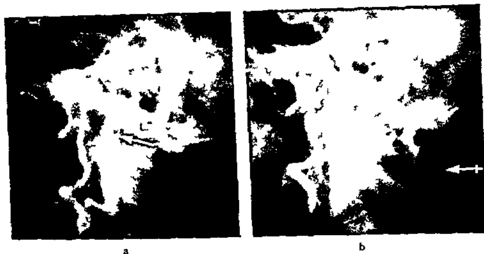


Fig 2 Case 2 External carotid angiograms Hypertrophied occipital artery with filling in the arterial phase of the jugular vein (←) (a) and of the deep cervical vein (←+) (b)

mosis is carried out (3 4 6 9 11, 25) If the defect that remains after excision is too great for primary repair a graft is used During arterial reconstruction of the carotid artery and to prevent cerebral ischemia temporary internal shunts may be provided by polyethylene tubing to maintain the cerebral blood flow External shunts may also be used the tube inserted proximally and distally to the opening of the fistula

Fistulas involving the vertebral artery should be treated differently from carotid fistulas because of the small size of the vessel Spontaneous closure of the vertebral fistula may occur as happened in one of our cases (10 14, 21, 23) However most cases require surgery Proximal ligation alone should not be performed since retrograde flow in the distal vertebral artery persists with possible formation of other collaterals The ideal treatment claimed by JAMIESON (16) is to expose the fistula and ligate it with preservation of the vertebral artery Otherwise as in the majority of cases, proximal and distal ligation of the vertebral artery with excision of the fistula should be done (23) Proximal and distal ligation alone without excision of the fistula or with partial excision of the fistula may not cure the lesion as happened in two of our cases (2 22)

We have had the opportunity to study seven cases of arteriovenous fistulas of the major vessels of the neck with varying etiologies, and wish to present six of these cases The first two were spontaneous in origin the third was an induced common carotid jugular fistula, and the last three were traumatic Since the appropriate surgical attack will depend upon accurate delineation of the fistu



Fig 3 Case 3 Right carotid angiograms a) and b) Large fistula between the right common carotid artery and the internal jugular vein c) After operation

lous tract the importance of angiography in localizing this, and in demonstrating the feeding vessel or vessels, will be emphasized

Spontaneous arteriovenous fistula of the vertebral venous plexus is rare and a few cases have been reported

Case reports

Case 1 although previously published will be briefly discussed It involved a fistula of the left vertebral artery with spontaneous cure or regression in a 61 year old woman who had sudden onset of left occipital pain followed two hours later by a loud noise in her head synchronous with the pulse The noise disappeared by turning the head to the left side On admission four weeks later a systolic murmur was heard at the apex of the left posterior triangle of the neck Compression of the left carotid artery did not influence the bruit

Left vertebral angiography was performed On the lateral view (Fig 1a) many veins of the cervical vertebral plexus were filled in the arterial phase The site of the fistula was not seen An anteroposterior peroral view (Fig 1b) showed clearly the fistula at the level of the third cervical vertebra No surgery was performed She was seen one year later, and was asymptomatic

Case 2 is another example of a spontaneous fistula fed by the occipital branch of the external carotid artery, and successfully treated The patient was a 65 year old housewife who noted the progressive development in severity of a noise in the left ear of one year



a



b



c

Fig 4 Case 4 a) Cervico-thoracic aortogram Large left vertebral artery a small right vertebral artery and large veins on the right upper portion of the neck b) Innominate arteriogram Small right vertebral artery stealing from the anterior circulation down the basilar artery but no filling of the venous plexus c) Left vertebral angiogram Retrograde flow into the distal portion of the right vertebral artery and into tremendously large veins



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Fig 6 Case 5 a) Innominate arteriogram Fistula fed by the right vertebral artery and by a large deep cervical artery (←) Many collaterals are seen arising from the transverse cervical artery (↦) b) Left vertebral angiogram Persistence of reflux down the right vertebral artery outlining the fistula (←) c) Innominate arteriogram The fistula is seen to be fed by branches of the transverse cervical artery d) Left vertebral angiogram The fistula (→) is still seen to be fed by reflux from the vertebral artery the vertebral vein is also filled (↦)

Case 4 is an illustration of a right vertebral arteriovenous fistula fed by the left vertebral artery with stealing from the anterior circulation and clinical symptoms of basilar artery insufficiency associated with a hyperdynamic mechanism without decompensation The patient was a young man who was shot beneath the right eye at the age of 15 He was operated in another hospital in order to stop the bleeding but details of this operation were not available He was admitted to our hospital 10 years later with dizziness headaches shortness of breath and a pulsatile mass on the right side of his neck

Cervico-thoracic aortography (Fig 4a) showed a large left vertebral artery a small right vertebral artery and large venous structures on the right upper portion of the neck Innominate arteriography Fig 4b) showed the small right vertebral artery well filled up to the first cervical vertebra Beyond this point only very small collateral branches were filled This type of appearance of the right vertebral artery was presumably due to the previous operation Stealing from the anterior circulation down the basilar artery was also noted N filling of the venous plexus was seen

Left vertebral angiography (Fig 4c) showed retrograde flow into the distal portion of the right vertebral artery and into tremendously large veins The right vertebral artery was ligated as a first step before directly attacking the fistula The patient however refused further surgery and has not been seen since

Case 5 is an example of an arteriovenous fistula of the right vertebral artery in which repeated attempts at surgical correction by proximal and distal ligation of the vertebral artery without excision of the fistula were made and without a surgical cure The angiograms



Fig 5 Case 5 a) Cervico thoracic aortogram Right vertebral fistula with a false aneurysm (→) and early filling of the vertebral vein (→→) b) Left vertebral angiogram Reflux down the right vertebral artery with outlining of the fistula and the false aneurysm drainage through the vertebral plexus and the vertebral vein c) Cervico thoracic aortogram Fistula is still seen failure of occlusion of the vertebral artery on both sides the ascending cervical artery and the deep cervical artery are hypertrophied

duration without apparent cause On examination the bruit was heard over the left mastoid region The bruit was synchronous with the pulse and disappeared on compression of the left carotid artery

Selective external carotid angiography showed (Fig 2a) a hypertrophied occipital artery with filling in the arterial phase of the jugular vein and (Fig 2b) of the deep cervical vein The venous plexus was excised and the occipital artery was clipped coagulated and cut Post operatively the patient was completely cured

Case 3 is one of induced carotid jugular fistula The patient was a 23 year-old male with mental retardation and convulsions of the left side of the body since early age At the age of 6 he was operated upon The right common carotid artery was anastomosed to the internal jugular vein in an attempt to increase the circulation to his right cerebrum in the belief that increased cerebral oxygenation would alleviate his condition He was admitted to this hospital in 1966 17 years later at the age of 23 with mild signs of cardiac decompensation A large pulsating mass in the right side of his neck was noted with a marked thrill and a bruit

Right carotid angiography (Fig 3 a and b) showed a large fistula between the right carotid artery and the internal jugular vein At surgery the fistula was resected with preservation of continuity of carotid artery (Fig 3c)



Fig 8 Case 6 a) Left vertebral angiogram Reflux down the right vertebral artery outlining the fistula (→) b) Right subclavian angiogram Hypertrophied ascending cervical (←+) and costocervical (←→) arteries c) Right innominate angiogram Small right vertebral artery filled up to the second cervical vertebral body the fistula did not fill

Case 6 is an example of a right vertebral arteriovenous fistula fed by the right and the left vertebral arteries and probably also by the right thyrocervical and costocervical arteries and in which ligation of the right vertebral artery above and below the fistula with excision of the fistula was attempted The patient was a 24 year old man who was stabbed with a pair of scissors behind and below the right ear three weeks prior to admission to hospital One week prior to admission he developed a buzzing sound in the right ear On admission a palpable systolic thrill and a systolic murmur were observed in the right suboccipital region

Right vertebral angiography Fig 7 showed an extensive arteriovenous fistula lateral posterior and superior to the first cervical vertebra Left vertebral angiography (Fig 8a) was then performed and showed reflux down the right vertebral artery from a hypertrophied left vertebral artery with filling of the fistula Right subclavian angiography (Fig 8b) showed hypertrophied ascending cervical and costocervical arteries Right external and common carotid arteriography showed no feeding vessels from these arteries to the fistula At operation an extensive arteriovenous fistula was found Most of the fistula was resected The right vertebral artery was ligated at C2 and at its entrance to the skull The bruit was not heard immediately after surgery but appeared three days later

Eight days after the operation right innominate angiography Fig 8c) was performed and showed a small right vertebral artery filled up to the level of the second cervical vertebral body The fistula did not fill above the metallic clips Left vertebral angiography (Fig 9) showed reflux down the right vertebral artery with contrast filling of the fistula which was

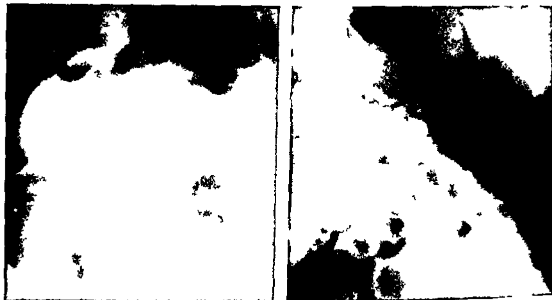


Fig 7 Case 6 Right vertebral angiogram showing an extensive fistula situated lateral posterior and superior to the first cervical vertebra

were of importance in outlining each time new feeding vessels The patient was a 19 year old male who was stabbed in the right side of his neck in October 1964 He was admitted to this hospital on June 1965 with dizziness and occipital headaches

Cervico thoracic aortography (Fig 5a) showed a right vertebral fistula with a false aneurysm with early filling of the vertebral vein Left vertebral angiography (Fig 5b) was then performed and reflux down the right vertebral artery was seen The fistula and the false aneurysm with drainage through the vertebral plexus and the vertebral vein were demonstrated Ligation of the right vertebral artery above C1 and at C5—C6 was performed The fistula was not excised

A second cervico thoracic aortography (Fig 5c) again showed the fistula with failure of occlusion of the right vertebral artery at either end There was some stenosis inferiorly and increase in the dilatation of the vertebral artery superiorly with definite stealing from the left vertebral artery The ascending cervical branch of the thyrocervical trunk and the deep cervical branch of the costocervical artery were hypertrophied The right vertebral artery was again ligated between C1—C2 and at its origin from the subclavian artery

Because the patient remained symptomatic innominate arteriography (Fig 6a) was performed three months after the second operation This once more showed the fistula to be fed by the right vertebral artery and by a large deep cervical artery Many collaterals were seen arising from the transverse artery Left vertebral angiography (Fig 6b) showed persistence of reflux down the right vertebral artery with filling of the fistula The patient underwent a third operation and again the right vertebral artery was ligated proximal and distal to the fistula The deep cervical artery was also ligated Post operatively the clinical symptoms were less severe but still present and at repeat innominate arteriography (Fig 6c) two months later the fistula was seen to be fed by branches of the transverse cervical artery Left vertebral angiography (Fig 6d) showed the fistula still to be fed from this artery The patient was lost to follow up

fistulas by proximal and distal ligation of the vertebral artery and excision of the fistula to obviate recurrence

In carotid artery jugular vein fistula excision of the fistula with lateral arteriorrhaphy or end to-end anastomosis is the treatment of choice The continuity of the jugular vein may be preserved or ligated

Angiography is also important in post surgical evaluation to establish the results of treatment

SUMMARY

Six cases of arteriovenous fistulas involving the major arteries and veins of the neck are reported Although the clinical diagnosis was obvious the precise anatomy of the feeding vessels and the exact site of the anastomoses could only be demonstrated by angiography The value of angiography in the evaluation and the surgical treatment of fistulas involving the vertebral artery is particularly emphasized

ZUSAMMENFASSUNG

Es wird uber sechs Falle von arteriovenosen Fisteln der grossen Arterien und Venen des Halses berichtet Obwohl die klinische Diagnose sicher war konnte die exakte Anatomie der Ernahrungsgefasse und die exakte Lage der Anastomosen nur durch Angiographie klar gelegt werden Besonders wird der Wert der Angiographie fur die Auswertung und der operativen Behandlung von Fisteln der A vertebralis betont

RÉSUMÉ

Les auteurs presentent six cas de fistule arterio-veineuse des grosses artères et des grosses veines du cou Bien que le diagnostic clinique soit evident seule l angiographie permet de preciser l anatomie des vaisseaux nourriciers et le siege exact de l anastomose Les auteurs insistent particulierement sur l intéret de l angiographie pour l etude et le traitement chirurgical des fistules qui intéressent l artere vertebrale

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Fig 9 Case 6 Left vertebral angiogram Reflux down the right vertebral artery again outlining the fistula (←) which is smaller than on the first examination the perivertebral veins filled in the antero posterior projection

much smaller than on the first examination The perivertebral venous structures were well seen The patient was operated on a second time The fistula was totally resected and the right vertebral artery was ligated distal to it Post operatively the patient was asymptomatic and the bruit disappeared At repeated left vertebral angiography no more reflux was observed down the right vertebral artery and the fistula was no longer apparent

Conclusion

Trauma is the major cause of arteriovenous fistulas of the major vessels of the neck Few reports have appeared of vertebral arteriovenous fistulas following percutaneous vertebral puncture The clinical diagnosis is obvious Angiography, however, will help to identify the feeding vessel or vessels When the vertebral artery is involved, it is important that vertebral angiography of the opposite side be performed, since often there is stealing from the opposite vertebral artery Furthermore the thyrocervical trunk and the costocervical artery may participate in feeding these fistulas, especially after incomplete or unappropriate surgery with failure to excise the fistula It is of utmost importance to treat vertebral

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REGIONAL CEREBRAL BLOOD FLOW IN PATIENTS WITH SUBARACHNOID HEMORRHAGE

by

L H ZINGESSER M M SCHECHTER J DEXTER R KATZMAN and L C SCHEINBERG

Quantitative estimation of cerebral blood flow may be carried out by a variety of methods some of which are eminently suited to the realm of clinical investigation This is an area where the neuroradiologist may use isotopes to supplement the delineation of abnormal anatomy provided by the angiographic method and to add another dimension to the physiologic information obtainable from serial angiography (CRONQVIST et coll 1965 1966)

Advances in the methodology of regional cerebral blood flow determinations using an inert diffusible indicator have made this method of cerebral blood flow measurement the most incisive method available at present (MCHENRY 1966) This method developed by LASSEN et coll (1961 1963) and their Swedish and Danish co-workers involves the monitoring by external counting of the washout of an inert diffusible indicator Modifications and refinements introduced over the last few years include injection of the isotope through a catheter placed in the internal carotid artery (to avoid the problem of correction for flow through the external carotid artery) recording on magnetic tape of the count rates obtained from the various regions and computer analysis of the curves obtained As performed by the Danish group this computer analysis utilizes the method of least squares in an analysis of the curve into two exponentials or alternatively calculates the flow using the stochastic approach Corrections for PaCO are incorporated in the computer program (HOEDT RASMUSSEN et coll 1966 1967)

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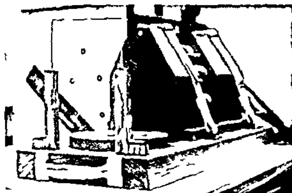


Fig 1 T indicates the plastic template with five radioopaque markers corresponding to the position of the collimated detectors A grid cassette is placed on the opposite side of the head (against the detectors) and a roentgenogram is obtained to indicate the position of the detectors.

seen in the area of ischemia has been attributed to the vasodilatory effects of post hypoxic tissue acidosis (LASSEN 1966) The anatomical basis for this luxury perfusion may be contained in the work of HASEGAWA et coll (1967) who have recently verified the presence in normal brain of precapillary arteriovenous anastomoses

Method

1 A group of 19 patients admitted to the Jacobi Hospital on the Cooperative Study of intracranial aneurysms and acute subarachnoid hemorrhage were the source of our clinical material

2 Angiography was performed bilaterally in all of these cases using local anesthesia the Seldinger technique with a PE 160 catheter advanced into the internal carotid artery and serial filming in a p and lateral projections Premedication if given was of modest amount

3 After a delay of one half hour following the injection of the last bolus of contrast material (the delay was necessary to avoid the effect of the contrast material (CRONQVIST personal communication) a localization film was obtained using a plastic template with radio-opaque markers corresponding to the position of the scintillation detectors (Fig 1) The isoresponse characteristics of our collimated detectors are illustrated in Fig 2 These were determined using a point source with the help of Miss G Connor physicist

4 An amount of 0 5 mCi of ¹³³Xe (Xeneisol © kindly supplied by the Neisler division of Union Carbide) dissolved in 5 ml saline was injected through the catheter in an interval of about *one second* A small amount of blood was then withdrawn from the carotid into the catheter to prevent further release of isotope from the dead space of the catheter

An attractive feature of the method is that the additional radiation exposure to the patient who has undergone angiography is negligible since the biologic life of the isotope used is approximately the carotid to lung circulation time This fact and the fact that both angiography and cerebral flow determinations may be carried out via the same catheter recommend the method to the neuro radiologist

One of the neuroradiologic problems that has interested us recently in the examination of patients with subarachnoid hemorrhage has been the evaluation of the relationship between the arterial spasm (sometimes present) delineated by angiography, changes in blood flow as determined by analysis of serial angio grams in these patients, and data obtained by use of the regional cerebral blood flow method The angiographic evaluation of spasm is based on analysis of arterial phases of the angiographic study with the spasm being categorized as local or diffuse A further descriptive classification based on the severity of the spasm divides cases into three groups (1) spasm, where the caliber of the vessel involved is narrowed by less than 50 %, (2) spasm, where the vessel is narrowed by more than 50 % and (3) spasm, where the vessel is barely visible

Since this is done without premorbid angiography for comparison it is often difficult to be sure whether or not narrowing of a vessel is due to spasm, hypo plasia or arteriosclerosis Angiographic circulation time studies may offer sup plementary information, but this may not be meaningful information Even if contrast material were an inert indicator, circulation time information can yield flow information only when the volume of the vascular tree is known Contrast material is not inert Circulation times are affected by the type of contrast ma terial used (GREITZ 1956) There is frequently an effect on heart rate and blood pressure (HILAL 1966) There is good evidence that the caliber of both arteries and veins is altered by contrast agents (HUBER et coll 1967, GREITZ 1956) Contrast materials cause clumping of red cells which may be severe in certain patients (McDOWELL et coll 1965) Furthermore circulatory dynamics may be altered by injection of a large bolus of contrast material via a catheter placed in the internal carotid artery, although they are apparently not altered by a small bolus of contrast injected in the carotid (GREITZ 1956) These considera tions apply in normal subjects In patients with spasm there is evidence that the spasm may be increased and perpetuated by contrast material (RAYNOR et coll 1960) Furthermore circulation time in patients with ischemia may be short rather than abnormally long According to a recent publication (GREITZ & REUTER 1966) 'in arterial occlusion the vein fills late However, there is angio- graphic evidence (PITTS et coll 1962) as well as other evidence (FEINDEL 1955 LASSEN 1966, INGVAR 1967, HOEDT RASMUSSEN et coll 1967) that this may not be the case Physiologically the rapid circulation (luxury perfusion) sometimes



Fig. 3. C indicates the collimated scintillation detectors. Immediately above the letter T is the 4-channel tape recorder. Background counts can automatically be subtracted during playback. Above P is a module for 4 channel pulse height analysis and on top of this is the dual rate computer. On the lower shelf is the high speed printer (H) and on top of this are two log linear ratemeters. The log linear ratemeters are interposed between the dual rate computer and the 2 pen recorder (A) for an analog read out with log count plotted against time.

$$\text{CBF (regional)} = 100\,\frac{I_1 \times 0.8k_1 + 0.53 I_2 \dfrac{k_1}{k_2} \times 1.5k_2}{I_1 + 0.53 I_2 \dfrac{k_1}{k_2}}$$

where I_1 = intercept of the fast component, I_2 = intercept of the slow component, k_1 = slope of the fast component and k_2 = slope of the slow component.

This formula is derived from LASSEN's equation taking into account the partition coefficients for ^{133}Xe.

No correction was made for recirculation realizing that this is small and that by not correcting for recirculation only a small under-estimation of flow results.

13. Circulation times were obtained from serial angiograms using the method of GREITZ (1956). Times for multiple regions were determined with the circulation time in each region representing the time from maximal contrast filling of the carotid siphon to maximal filling of the veins of the region.

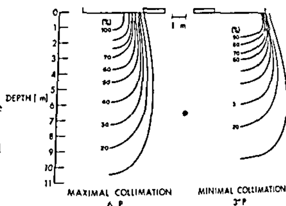


Fig 2 Isoresponse characteristics single probe with Swiss cheese collimation ^{197}Hg = 0 078 MeV The flare of the 10 % isoresponse curve with three inches of lead collimation (right) passes only slightly beyond the midpoint of the septum between collimated detectors, there is therefore little crosstalk

5 Count rates from four regions were recorded, using four scintillation detectors, 1 to 1/2 inches by 1/4 inches (2 5 to 1 7 cm by 0 85 cm) recessed behind 3 inches (7 6 cm) of lead (Fig 3) After pulse height analysis the signals were taped This was done on Picker s Digitape-4 This equipment includes digital and buffer storage to derandomize pulses Later the taped channels were played two at a time into a Picker Dual Rate Computer, which is essentially a dual scaler system with a buffer storage unit so that counts can be displayed and printed out while other counts are being accumulated This cycle requires only 10 microsecond Counts were obtained every second during the first minute of the washout, and every ten seconds thereafter for a total of about 12 minutes Display was via an analog output using log rate meter circuits for a log counts vs time plot on a two pen recorder system, and also digital information was obtained using a parallel entry Monroe Printer

6 Background counts were obtained before and after the washout recording for corrections when necessary

7 Blood was withdrawn from the carotid artery for $PaCO_2$ determinations using a membrane electrode method

8 When bilateral determinations were performed, enough time was allowed to elapse following the first injection of ^{133}Xe so that no correction was necessary in the analysis of the contralateral washout curve

9 Washout curves were constructed from the digital information

10 The curves were analyzed graphically in order to find the exponentials involved in the makeup of the curve

11 Using the partition coefficients for ^{133}Xe obtained by VEALL & MALLET (1965), calculations were made for flow in the fast compartment and flow in the 'slow compartment

12 Calculation of average 10 minute flow was made taking into account the weights of the brain substance in the two compartments according to the formula

Table 1

Results of regional flow determinations in ten normal volunteers

Subject	Age	Anterior frontal	Posterior frontal	Parietal	Temporal occipital	Mean	S D
(1)	40	45.0	41.0	40.5	44.6	42.8	2.0
(2)	49	59.8	63.6	57.3	40.8	55.4	8.7
(3)	29	53.3	59.0	54.3	45.0	52.9	6.0
(4)	29	58.8	55.3	48.5	—	54.2	4.3
(5)	23	44.8	59.3	67.3	65.4	59.2	8.9
(6)	43	44.9	49.7	44.3	36.4	44.0	4.9
(7)	35	35.2	50.7	52.5	47.3	46.4	6.8
(8)	27	55.0	68.5	58.8	44.3	56.7	7.1
(9)	26	57.6	64.6	50.8	54.0	56.8	5.2
(10)	29	71.0	74.5	64.4	58.0	67.0	6.3
	Mean	52.5	58.6	53.9	48.9		
	S D	9.7	7.9	7.9	8.5		

this series is demonstrated in Table 2. In general there is a poor correlation. Reduction in blood flow is found even in the absence of spasm. Also spasm noted in five of the nineteen patients is not necessarily associated with a diminution of blood flow in the vascular territory distal to the spasm (although in certain individual cases such as the patient illustrated in Fig. 5 the diminution in blood flow correlates nicely with the location of the spasm). In one of the patients higher flow values were found postoperatively in the presence of spasm than preoperatively in the absence of spasm.

In cases in which bilateral determinations were made there was frequently bilateral depression of flow. Bilateral depression of flow has been noted with unilateral lesions by others (HOEDT RASMUSSEN 1964).

Two patients with subarachnoid hemorrhage as the result of rupture of small arteriovenous malformations were studied. Contrary to the results of HAGGENDAL (1965) early peaks were not seen in these patients, probably because of the small size of the malformations. Only one of them had supernormal flow.

Discussion

The significance of spasm associated with rupture of a cerebral aneurysm has interested many workers. The etiology of the spasm remains obscure. Its significance in the etiology of infarction is debated. STORNELLI & FRENCH (1964) and ALLCOCK & DRAKE (1965) indicate that spasm has great prognostic significance.

In discussing the pathogenesis of infarcts in patients with subarachnoid hemorrhage POOL (1958) attaches significance to the presence of spasm. CROMPTON

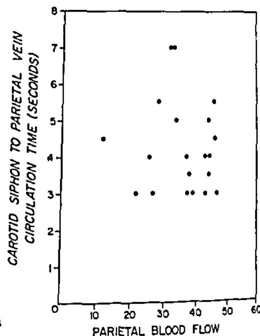


Fig 4 Lack of correlation between circulation time and regional blood flow (ml/100 g/min)

The presence or absence of spasm was noted and the spasm was graded according to the classification presented in the introduction

14 A group of 10 normal volunteers at the Sing Sing Penitentiary in Ossining N Y, had cerebral flow studies according to the above method in order to better establish normal values The ages of these volunteers ranged from 23 to 49 years

Results

The results of regional flow determinations carried out in 10 normal volunteers, ranging in age from 23 to 49 years, are given in Table 1 Mean flows and standard deviations are calculated for each of the volunteers and for each of the four areas studied the anterior frontal region, the posterior frontal region, the parietal region, and the occipital region The results are expressed in ml/100 g/min The results are approximately the same as other workers have found in the few small series of normal subjects reported to date (INGVAR et coll 1965, FIESCHI et coll 1966, HOEDT RASMUSSEN 1967) We have found, as did INGVAR, that the flow in the occipital area, 48 9 ml/100 g/min is slightly less than elsewhere

Fig 4 represents the scattergram obtained when circulation time in the parietal region in patients with subarachnoid hemorrhage is plotted against regional cerebral blood flow in the parietal area There is obviously a poor correlation

The correlation between spasm and regional flow in each of the patients in

Table 2 *(cont.)*

Anterior frontal	Posterior frontal	Parietal	Temporal	Occipital	Pa CO	Focal signs
Left 35 0		36 7	53 0	35 9		Right central facial paresis
Right 40 3	26 1	25 1		25 1		0
Left 49 2		21 3	29 4	29 6		Minimal right corticospinal
Right 41 1	34 6	45 0		47 3		0
Right 45 3	39 6	42 3		45 2		0
Left 35 9		36 3	36 4	30 7	35 0	Right hemiparesis
Right 26 7	45 3	37 2		36 2	33 5	0
Right 42 2	43 2	43 3		41 3	41 4	0
Left 31 5 Right 31 3	 24 0	27 4	33 1 31 9	24 5 35 3		0
Right 31 5	38 8	33 0	33 0	29 0	38 9	Minimal left corticospinal
Left 49 5		45 6	50 1	44 1		
Right 38 2	31 6 40 5	36 3 34 9	29 3	35	41 5	Left hemiparesis
Right 78 8	59 0	46 3		49 0	38 1	0
Left 47 0		43 3	50 5	44 7		Right hemiparesis aphasia
Right 25 1	26 6	31 1		29 9	25 8	Left homonymous hemianopsia
Right 35 2	34 7	42 1		23 3	27 2	Left homonymous hemianopsia

Table 2

Results of regional cerebral flow determinations

Case	Age	Sex	Diagnosis	Spasm
D D	47	Female	No source	0
N D	65	Male	Right middle carotid artery aneurysm	0
A N	25	Female	Anterior communicating artery aneurysm	
W R	21	Male	Anterior communicating artery aneurysm	0
M W	30	Female	No source	0
B W	31	Female	Left internal carotid artery aneurysm	Grade 2 Segmental internal carotid artery and anterior cerebral artery
G K	47	Female	Right internal carotid artery aneurysm	0
G K	47	Female	Postoperative clipping of aneurysm neck	Grade 2 Segmental
J I	65	Male	Left middle cerebral artery aneurysm	0 0
Z I	20	Female	Anterior communicating artery aneurysm	Grade 2 Segmental internal carotid artery and anterior cerebral artery Grade 2 Segmental internal carotid artery and anterior cerebral artery
N S	18	Female	Small arteriovenous malformation in right thalamus	0
R F	35	Female	Arteriovenous malformation right frontal	0
E G	46	Male	Left temporal hematoma (hypertensive hemorrhage)	0
T C	61	Male	Right internal carotid artery aneurysm hematoma right temporal	0
T C	61	Male	Postoperative clipping of aneurysm neck	0

Table 2 *(cont)*

Anterior frontal	Posterior frontal	Parietal	Temporal	Occipital	Pa Co_2	Focal signs
Left 39 4		36 1	42 9	34 4	26 2	Slight drift right upper extremity and central facial weakness
Left 12 3		11 4	8 5	11 7	31 2	Right hemi paresis aphasia
Right 31 6	30 9	26 3		27 0		
Left 36 5	37 7	38 3		40 8	35 0	0
Right 37 3	42 5	42 0		39 4		
Right 29 8	32 6	35 2		35 6	25 3	0
Left 25 9	27 7	30 1		26 3		
Right 16 3	25 3	12 4		24 1		Left hem paresis and facial paralysis
Left 40 4		40 2		35 2		
Right 33 2	38 3	43 8		38 8	30 4	Left facial paresis
Right 31 0	34 1	36 5		35 7	36 6	Left facial paresis

in 62 % of cases with infarcts while 38 % without narrowing had encephalomalacia Vasospasm also occurred in 57 % of those patients who had no infarcts

Diagnostic and therapeutic procedures intervening before the post mortem analysis of the material as they do in the study cited above make a closely reasoned approach to the analysis of individual infarcts difficult if not impossible Problems peculiar to an angiographic approach to such a problem are complicated still further by the observations that spasm is sometimes transient being present after one injection and not after another injection Furthermore infarcts at times are not found in the distribution of the spastic vessels

The results of our comparison of angiographic circulation time data with the data obtained from regional cerebral flow determinations indicate that flow in patients with subarachnoid hemorrhage cannot be evaluated well with circulation time data Why this is so perhaps requires some explanation Circulation time information does not yield flow rates unless the volume of the vascular bed is known The circulation may indeed be very rapid when the vascular bed is

Table 2 *(cont.)*

Case	Age	Sex	Diagnosis	Spasm
S P	59	Male	Anterior communicating artery aneurysm Small right frontal hematoma	0
Z W	48	Female	Aneurysm at left internal carotid artery Bifurcation and small aneurysm left middle cerebral artery	Grade 1 Diffuse anterior cerebral artery and middle cerebral artery
M B	63	Female	Anterior communicating artery aneurysm	0
W I	63	Male	Left intracerebral hematoma Deep frontal	0
W I	37	Female	Right middle cerebral artery aneurysm	Grade 2 Segment middle cerebral artery proximal to aneurysm
G R	37	Female	Right internal carotid artery aneurysm	0
G R	37	Female	Postoperative clipping of aneurysm neck	0

in two articles (1964) and SCHNECK (1964) indicate the importance of factors other than spasm in the pathogenesis of infarction. According to CROMPTON, large subarachnoid hematomas, especially in the Sylvian fissure cause stretching and kinking of, and necrotic changes in the walls of perforating vessels, with stasis and vasoconstriction. Blood from the subarachnoid space is forced into the perivascular spaces of the ganglionic arteries. Increased intracranial pressure impedes circulation through collaterals. Swelling of the brain after infarction causes a further rise in the intracranial pressure. According to SCHNECK cerebral vasospasm by itself does not seem to be the most significant cause of cerebral infarctions. At most it accounted for only 28 % of the infarcts in his study. Diagnostic and therapeutic procedures were felt to account for the bulk of the infarcts. However, a review of the case material after the films had been re-examined by a neuroradiologist (I. KRICHEFF) did disclose that spasm in cases with infarcts was almost always marked and diffuse. This was less frequently seen in cases without infarction. Nevertheless, even after review, vasospasm was present

Table 2 *(cont.)*

Anterior frontal	Posterior frontal	Parietal	Temporal	Occipital	PaCO2	Focal signs
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Left 36 5	37 7	38 3		40 8	35 0	0
Right 37 3	42 5	42 0		39 4		
Right 29 8	32 6	35 2		35 6	25 3	0
Left 25 9	27 7	30 1		26 3		
Right 16 3	25 3	12 4		24 1		Left hemiparesis and facial paralysis
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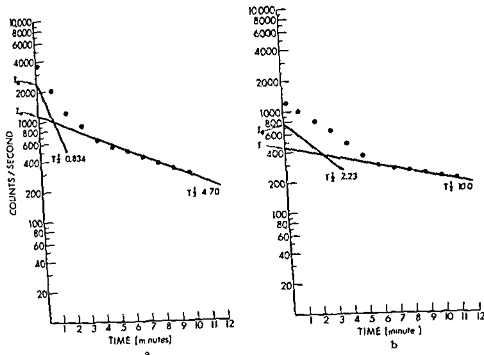


Fig 6 Flow determinations bilaterally in the patient with middle cerebral artery aneurysm (cf fig 5a) Moderate to severe reduction in flow distal to the spastic segment M1 on the right

a) CBF ml/100 g/min	
Left anterior frontal	=40 4
Left parietal	=40 ?
Left occipital	=35 2

b) CBF$_f$ ml/100 g/min	
Right anterior frontal	=16 3
Right posterior frontal	=25 3
Right parietal	=12 4
Right occipital	=24 1

found a poor correlation between circulation time and regional flow in a group of patients with cerebrovascular disease

GREITZ (1956) previously found that a good correlation existed between circulation time measurements as determined angiographically and using an inert non-diffusible isotopic indicator However in GREITZ s studies the contrast material and the isotope were injected simultaneously

Our findings regarding a poor correlation between circulation time and regional flow may reflect an effect of the contrast material on the cerebral vessels A statement contained in recent publications (HILAL 1966) on carotid and cerebral blood flow determinations using a densitometric method indicates that all the hemodynamic disturbances resulting from the injection are slow in onset They start after the flow determination has been completed Other references



Fig 5 a) A middle cerebral aneurysm arising at the trifurcation (arrows) grade 2 spasm in the M1 segment immediately proximal to the aneurysm Anterior cerebral artery not filled both anterior cerebral arteries filled from the left side injection no spasm on the left side b) Radio opaque markers indicate the position of the scintillation detectors

reduced In order for circulation time or mean transit time ($\bar{t}$) to serve as a linear index of CBF $\frac{1}{\bar{t}} = \frac{F}{V}$ two assumptions must be fulfilled These are that (1) the recorded curve of radioactivity vs time gives reliable information about the mean transit time and (2), the cerebral blood volume must be constant (ZIERLER 1964) It seems unlikely that the cerebral blood volume is constant in patients with subarachnoid hemorrhage who have varying intracranial pressures Even in healthy male volunteers NYLIN et coll (1961) found that the cerebral blood volume measured with labelled erythrocytes varied between 70 and 135 ml

In addition, however, there is the possibility that the contrast materials used in angiography alter the volume of the cerebrovascular bed One pertinent paper in this respect is that of FIESCHI et coll (1966), these authors found that the mean transit time in cerebral vessels (of 27 patients, eight of whom were normal and nineteen of whom had cerebrovascular disease) correlated in a linear though approximate way with regional cerebral blood flow determinations performed with [8] Kr However, the confidence limits of FIESCHI s regression equation are high, and it is stated that a wide range of values of CBF can be expected for any observed values of $\bar{t}$ To give an example, a $\bar{t}$ of 5 seconds tolerates CBF values ranging from 24—46 ml/100 g/min In our studies, where the correlation between circulation time and CBF was poorer, contrast material was substituted for an inert isotopic indicator of circulation time CRONQVIST et coll (1965, 1966) using contrast material for measurements of circulation time also

RÉSUMÉ

Il est facile d effectuer en meme temps que l angiographie des mesures du debit cérébral regional qui apportent des renseignements complementaires Une série de 10 sujets normaux etudies par la methode de débit régional avaient approximativement le meme débit que celui qui a eté trouve sur plusieurs petits groupes de sujets normaux La corrélation entre le temps de circulation determine angiographiquement chez des sujets atteints d hémorragie sous arachnoidienne et le débit cérébral regional est assez mauvaise de meme en general la corrélation est mauvaise entre le debit cérébral regional et la presence ou l absence de spasme bien que cette corrélation soit tres bonne dans certains cas En général le debit est diminue chez les malades atteints d hemorragie sous arachnoidienne Dans certains cas cette diminution est tres nettement régionale beaucoup plus marquee dans certaines régions que dans d autres Dans plusieurs cas on a constaté une diminution bilatérale du debit

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HASEGAWA T RAVENS J R and TOOLE J F Precapillary arteriovenous anastomoses Arch Neurol 16 (1967) 217

HILAL S K (a) Hemodynamic changes associated with intra arterial injection of contrast media Radiology 86 (1966) 615

— (b) Human carotid flow determination using a radiographic technique Invest Radiol 1 (1966) 113

supporting a point of view contrary to the quoted reference above are contained in the introduction to this paper in the remarks on the effect of contrast materials. Especially pertinent is the paper by HUBER & HANDA (1967). These workers cite the previous papers indicating mixed views as to the affect of contrast materials on cerebral vessels. They found a dilatation of vessels, especially of the smallest measurable arteries (0.5 *mm to* 1.0 *mm*) *of their material following* the injection of Urografin 60 %. They attributed this to the hypertonicity of the contrast material. They give a cogent explanation for the discrepancy between their findings and HILAL's (1966a).

Acknowledgement

This work was supported by Grant 1 RO1 NB 06431 of the National Institute of Neurological Diseases and Blindness, National Institutes of Health. The authors wish to express their appreciation to H. Kipp and S. Meyer for their assistance with the regional cerebral flow determinations on the normal volunteers at Sing Sing Penitentiary.

SUMMARY

Regional cerebral flow determinations affording supplementary information may easily be carried out in conjunction with angiography. A series of 10 normal subjects studied with the regional flow method had approximately the same flow as was reported for several other small groups of normal subjects. The correlation between circulation time as determined angiographically in patients with subarachnoid hemorrhage and the regional cerebral flow values, as well as generally between the regional cerebral flow and the presence or absence of spasm was poor though striking for the latter in certain cases. Generally the flow was depressed in patients with subarachnoid hemorrhage. At times the depression was strikingly regional, much more severe in some areas than in others. Bilateral depression of flow was seen in several cases.

ZUSAMMENFASSUNG

In Verbindung mit Angiographie sind Bestimmungen der regionalen Hirndurchblutung einfach durchzuführen und ergänzen die angiographisch ermittelten Befunde. Die von den Verfassern ermittelte regionale Durchblutung von 10 gesunden Patienten war ähnlich wie sie von anderen Autoren mit kleinen Gruppen von gesunden Patienten berichtet wurde. In Patienten mit subarachnoidaler Blutung bestand nur eine vage Korrelation zwischen der regionalen Durchblutung und der angiographisch ermittelten Zirkulationszeit. Eine allgemein schwache Korrelation ergab sich auch zwischen dem regionalen Blutdurchfluss und der Anwesenheit oder Abwesenheit von Gefäss-Spasmen, obgleich in bestimmten Fällen ein überraschender Zusammenhang bestand. In Patienten mit subarachnoidaler Blutung war die Durchblutung im allgemeinen vermindert. Gelegentlich war die Verminderung auffällig auf ein bestimmtes Gebiet beschränkt, oder war viel schwerwiegender in bestimmten Gebieten als in anderen. In mehreren Fällen wurde bilaterale Verminderung der Durchblutung beobachtet.

RÉSUMÉ

Il est facile d effectuer en meme temps que l angiographie des mesures du débit cerebral regional qui apportent des renseignements complementaires Une série de 10 sujets normaux etudies par la methode de debit régional avaient approximativement le meme debit que celui qui a été trouvé sur plusieurs petits groupes de sujets normaux La correlation entre le temps de circulation determiné angiographiquement chez des sujets atteints d hé morra ie sous arachnoidienne et le debit cérébral regional est assez mauvaise de meme en general la correlation est mauvaise entre le debit cerébral regional et la presence ou l absence de pa me bien que cette correlation soit tres bonne dans certains cas En géneral le debit e t diminué chez les malades atteints d hemorragie sous arachnoidienne Dans certains cas ett diminution est tres nettement regionale beaucoup plus marquée dans certaines regions que dans d autres Dans plusieurs cas on a constaté une diminution bilatérale du debit

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supporting a point of view contrary to the quoted reference above are contained in the introduction to this paper in the remarks on the effect of contrast materials. Especially pertinent is the paper by HUBER & HANDA (1967). These workers cite the previous papers indicating mixed views as to the affect of contrast materials on cerebral vessels. They *found a dilatation of vessels, especially of the* smallest measurable arteries (0.5 mm to 1.0 mm) of their material following the *injection of Urografin 60 %*. They attributed this to the hypertonicity of the contrast material. They give a cogent explanation for the discrepancy between their *findings* and HILAL's (1966a).

Acknowledgement

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RADIOISOTOPES

ISOTOPE CISTERNOGRAPHY AND VENTRICULOGRAPHY

by

GEORGE J ALKER JR and EUGENE V LESLIE

Isotope cisternography consists of the lumbar intrathecal injection of a radioactive material and following its course in the subarachnoid pathways by means of serial scintillation scanning It makes it possible to evaluate the cerebrospinal fluid circulation with minimum disturbance of the existing flow pattern In the case of isotope ventriculography the radioactive material is injected directly into a cerebral ventricle Since these procedures were first introduced by DI CHIRO (1963 1964 1966) they have slowly gained acceptance (2 16 17 23) and drew attention to abnormalities related to disturbed cerebrospinal fluid circulation which up to now were difficult to diagnose In this paper based on our experience with over 50 cisternographies and ventriculographies our technique is described and the usefulness of these procedures is illustrated by means of case reports from each of the two major areas of application namely the demonstration of cerebrospinal fluid fistulae and the evaluation of hydrocephalus

Technique

Ten drops of Lugol s solution are administered three times a day for 3 days beginning the day before the examination for the purpose of reducing the uptake of liberated ^{131}I by the thyroid gland On the morning of the examination a

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injection To our knowledge, aseptic meningitis has been reported in only one other patient in the literature (6) Both of these patients recovered without residue in a few days Although in the past we have used serum albumin containing as much as 360 mg of protein per injection, at the present time our average dose contains 10 to 20 mg of protein (1 to 2 ml of 1 % RIHSA solution) The dose injected into a cerebral ventricle for isotope ventriculography is 50 μCi

The two main indications for cisternography are cerebrospinal fluid leak and the evaluation of hydrocephalus DI CHIRO suggests other disease entities that may be demonstrated by these studies These include porencephalic cyst subdural hematoma spontaneous ventriculostomy and intraventricular tumors (8 11 13 14 15)

The only *contraindication* seems to be allergy to the isotope employed

Scintiscan findings

Normal appearances The isotope injected into the lumbar subarachnoid space spreads toward the head in the spinal canal independent of the patient's position (21) The mechanism of this spread is as yet unexplained It is quite possible that in the spinal canal this is merely a matter of diffusion in fluid However intracranially a current of cerebrospinal fluid appears to be operating As the isotope reaches the cranial cavity it enters the basilar cisterns then spreads over the Sylvian fissures and frontal poles and thence over the cerebral hemispheres (Fig 1) Eventually most of it collects along the superior sagittal sinus Although absorption is thought to occur everywhere in the subarachnoid spaces the bulk of the injected albumin is absorbed into the superior sagittal sinus Normally none of the isotope enters the cerebral ventricles It has been shown by BERING (1967) and others that the net flow of cerebrospinal fluid in the aqueduct and fourth ventricle is caudad carrying the cerebrospinal fluid produced in the lateral and third ventricles out into the subarachnoid spaces From there the current of cerebrospinal fluid described above carries it to the region of the superior sagittal sinus where much of it is absorbed

Cerebrospinal fluid fistula Isotope cisternography is a relatively simple way of demonstrating cerebrospinal fluid fistulae which may be quite difficult to demonstrate by other means (5) In some of our patients nasal packs were employed These packs were then examined in a well scintillation counter at 24 hours for evidence of radioactivity It was found however that when RIHSA is used some of the iodine which has been absorbed into the blood stream is excreted by the nasal mucosal glands and salivary glands into the nasal discharge and saliva Therefore the mere presence of radioactivity in nasal packs is not necessarily an indication of cerebrospinal fluid fistula An unusually large

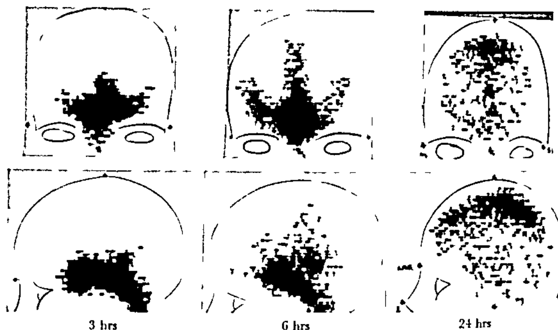


Fig. 1. Normal isotope cisternograms. Anterior and left lateral positions at 3, 6 and 24 hours after lumbar intrathecal injection of RIHSA. At 3 hours the isotope arrives in the basilar cisterns; it then spreads in the basilar cisterns, passes over the frontal poles and cerebral convexities and, by the end of 24 hours, it collects along the superior sagittal sinus where most of it is absorbed into the blood.

lumbar puncture is performed using a small gauge spinal needle (22 G) to minimize leakage at the puncture site. Pressure is measured and samples of fluid are collected for routine laboratory analysis. One hundred μCi of radioiodinated human serum albumin (RIHSA) are injected into the lumbar subarachnoid space. Scanning of the head is performed at 3, 6 and 24 hours after injection. Occasionally, a 48 hour scan is necessary when flow is slower than average or when a more accurate assessment of the rate of absorption is desirable. Several authors have advocated the use of high specific activity radioiodinated human serum albumin because of the danger of aseptic meningitis caused by the foreign protein (6, 10, 12, 19). In our experience, this has appeared only once, although transient temperature elevation is occasionally observed a few hours after the



Fig. 2. Cerebrospinal fluid fistula. Frontal skull fracture 2 weeks before cisternography and pneumococcal meningitis a few days after the accident. The cisternographic examination at 24 hours after injection demonstrates extravasation of the isotope into the right frontal, ethmoid and maxillary sinuses. (At surgery a fistula between the frontal subarachnoid space and the right frontal sinus was found.)



Fig 4 Normal pressure hydrocephalus Post operative isotope ventriculogram 2 months after ventriculo-atrial shunting The ventricles are definitely smaller than pre-operatively (compare with fig 3)

fluid the result is compensated hydrocephalus and the patient may be asymptomatic If, however at least under periods of temporarily increased demand the absorption capacity lags behind fluid production the result is the clinical entity of normal pressure hydrocephalus, the hallmarks of which are gradual intellectual deterioration particularly impairment of memory and ataxia. The syndrome was first reported by ADAMS and co-workers in 1965 who named it normal pressure hydrocephalus They also reported that ventriculo-atrial shunting of these patients often results in dramatic alleviation of the symptoms On the other hand hydrocephalus associated with cerebral atrophy but normal cerebrospinal fluid circulation does not usually respond to the shunting procedure In our experience isotope cisternography promises to be an excellent examination to help select those patients in whom a ventriculo-atrial shunt is likely to be of benefit

Case report A 55 year-old man suffered a cerebral concussion in an auto accident a year before coming to our hospital Following the injury he underwent gradual intellectual deterioration He was unable to hold a job whereas before the accident he had worked at two jobs simultaneously His memory had become quite poor and he developed ataxia The cerebrospinal fluid pressure was normal Encephalography revealed communicating hydrocephalus with rather marked dilatation of the cerebral ventricles Only a small amount of air was seen in the basilar cisterns and none over the cerebral hemispheres As is characteristic of this disease his general condition worsened markedly for a few days after encephalography and he became quite lethargic

We reasoned that because of the obliteration of the subarachnoid spaces over the cerebral hemispheres the spinal fluid circulation was altered To prove this isotope cisternography was performed (Fig 3) At 3 hours the cerebral ventricles began to fill At 24 hours essentially all of the isotope was in the ventricles At 48 hours the distribution of the isotope remained the same but activity was decreasing as absorption was taking place

No radioactivity was detected over the cerebral hemispheres We concluded from this that our patient was unable to absorb all of the cerebrospinal fluid because of a blockage of the cerebrospinal fluid pathways in the region of the tentorial notch He was absorbing much of the cerebrospinal fluid from the ventricles which were apparently unable to fully compensate the system The picture fitted the diagnosis of normal pressure hydrocephalus

A ventriculo-atrial shunt was performed with immediate improvement of the patient's condition Two months later the shunt had to be revised and at that time isotope ventriculography was performed (Fig 4) which showed that the ventricles were already much smaller than pre operatively

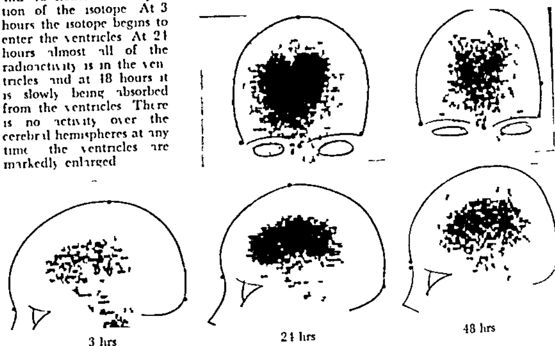


Fig. 3. Normal pressure hydrocephalus. Preoperative cisternograms 3, 24 and 48 hours after injection of the isotope. At 3 hours the isotope begins to enter the ventricles. At 24 hours almost all of the radioactivity is in the ventricles and at 48 hours it is slowly being absorbed from the ventricles. There is no activity over the cerebral hemispheres at any time; the ventricles are markedly enlarged.

amount of radioactive material or asymmetry between the two sides may be considered suggestive but not diagnostic of a leak. We are no longer using nasal packs in these patients.

Isotope cisternograms of a 10 year old boy with a frontal skull fracture involving the anterior wall of the right frontal sinus are shown in Fig. 2.

Normal pressure hydrocephalus. This is a recently described clinical entity in which the underlying pathology is a disturbance of the cerebrospinal fluid flow pattern. When blockage of the intracranial subarachnoid pathways occurs in the basilar cisterns, or anywhere over the cerebral convexities, or when absorption into the superior sagittal sinus becomes impossible due to a local abnormality of the absorption mechanism, the fluid produced in the ventricles (and the isotope injected in the lumbar subarachnoid space) must seek alternate routes of flow. It is believed that under these circumstances the walls of the lateral ventricles are able to take over some of the functions of absorption (3, 14). Dilatation of the lateral ventricles occurs which apparently increases the absorption capacity of the ventricular walls. Eventually, an equilibrium is reached and the process of enlargement of the lateral ventricles is arrested. If the absorption capacity is then able to keep pace with the production of cerebrospinal

ZUSAMMENFASSUNG

Isotopen Zisternographie und Ventrikulographie werden diskutiert und die Verfasser beschreiben ihre Technik eingehend Es wird hervorgehoben dass diese Untersuchungen von besonderem Wert sind um Zerebro pinalflus igkeitsfisteln und abnorme Flussigkeitsverhaltnisse nachzuweisen besonders bei der Diagnose von Normaldruck Hydrocephalus

RÉSUMÉ

Les auteurs etudient la cisternographie et la ventriculographie isotopiques Ils decrivent en detail une technique Ces examens sont utiles pour mettre en evidence les fistules du liquide céphalo rachidien et les anomalies de la circulation du liquide cephalo-rachidien en particulier dans le diagnostic des hydrocephalies a pression normale

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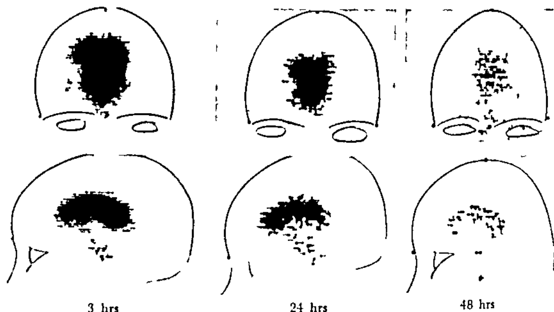


Fig 5 Normal pressure hydrocephalus Postoperative isotope cisternogram one year after ventriculo atrial shunting The ventricles are much smaller than pre operatively the flow of the isotope into the ventricles and removal of it from the ventricles are much faster than pre operatively (compare with fig 3)

A year later repeat cisternography (Fig 5) showed further reduction in ventricular size Another very definite finding was that the flow of the isotope into the ventricles and its removal from the ventricles was much faster postoperatively than pre operatively At 48 hours almost all of the injected isotope was already gone from the ventricles indicating that the shunt was functioning quite well The rapidity of absorption or removal by a shunt of the injected isotope appears to influence the rate of flow towards the site of absorption or removal The patient showed marked improvement during the first year after surgery and returned to work as a tractor driver

Conclusion

On the basis of our experience with isotope cisternography and ventriculography, we feel that these examinations are helpful new tools for the neuro radiologist, particularly in the evaluation of cerebrospinal fluid fistulae and ab normal cerebrospinal fluid flow patterns It is quite likely that these examinations will gain wider acceptance in the future and that other areas of usefulness will be found

SUMMARY

Isotope cisternography and ventriculography are discussed and the authors technique is described in detail These examinations are useful for the demonstration of cerebrospinal fluid fistulae and abnormal cerebrospinal fluid flow patterns particularly in the diagnosis of normal pressure hydrocephalus

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DEBIT HEMATIQUE CEREBRAL DETERMINE PAR XENON 133 DANS LES LESIONS CEREBROVASCULAIRES A FOYER ISCHEMIQUE ET SES CORRELATIONS CLINICO ANGIOGRAPHIQUES

par

P D AMICO et M MINAZZI

Nous avons calcule le debit hematique cerebral chez un groupe de 27 malades atteints des lesions cerebrovasculaires a foyer ischemique injectant dans la carotide interne 400 μCi de ^{133}Xe en enregistrant les courbes de dé puration du traceur au moyen de deux detecteurs places en region parieto temporo centrale des deux cotes Le placement de l aiguille est controlé a la lumiere de Wood apres injection de fluorine 5 % Toutes les determinations ont ete bilaterales sauf pour 9 malades atteints de thrombose carotidienne auxquels on a calcule seulement le debit controlateral Les valeurs du debit hematique cerebral ont éte calcules en ml/100 g/min d apres la methode de LASSEN & INGVAR (1963)

Les resultats dans les sujets normaux sont semblables aux donnees de la litterature le debit moyen ($\bar{f}$) a ete 52 5 $\pm$ 3 8 ml/100 g/min la composante rapide (f) 70 7 ml $\pm$ 6 6 et la composante lente (f) 18 9 $\pm$ 5 9 ml

On a aussi calcule le rapport (hH/hC) entre la hauteur de la courbe homolatérale à l injection et celle controlatérale dans les sujets normaux il a été 3 30 $\pm$ 0 77 Pour verifier cette valeur nous avons fait des épreuves avec un

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Tableau 2

Corrélations entre débit hématique cérébral homolatéral et données cliniques

	Probabilité	Variance expliquée
1 $\bar{f}$ → Examen neuropsychique + évolution	80	33 %
2 $\bar{f}$ → Évolution	90	20
3 f → Examen neuropsychique + évolution	80 %	28 %
4 f → Examen neuropsychique	80 %	21

Tableau 3

Corrélations entre débit hématique cérébral controlatéral et données cliniques

	Probabilité	Variance expliquée
1 $\tilde{f}$ → Examen neuropsychique + évolution	95 %	41 %
2 $\tilde{f}$ → Évolution	99 %	36 %
3 f → Évolution	90 %	9 %
4 hH/hC → Évolution	90	9

Tableau 4

Corrélations entre débit hématique cérébral et examens artériographiques et EEG

	Probabilité	Variance expliquée
1 f homolatéral → Artériographie	80	16
2 f homolatéral → Artériographie	0	0
3 f controlatéral → Artériographie	<80 %	6
4 f controlatéral → Artériographie	80 %	6,9 %
5 f homolatéral → EEG	80	11
6 hH/hC → Artériographie	99	38

ordre sont les corrélations entre $\bar{f}$ et l'évolution, f_1 et examen neuropsychique + évolution et enfin entre f_2 et examen neuropsychique.

Pour le débit hématique cérébral controlatéral on a observé les corrélations plus étroites entre $\tilde{f}$ et examen neuropsychique + évolution et $\tilde{f}$ et l'évolution toute seule. Il y a des corrélations bien plus faibles entre f_1 et l'évolution et aussi entre hH/hC et l'évolution.

Parmi les corrélations entre le débit et les données angiographiques et électroencéphalographiques on relève les plus significatives entre f_1 homolatéral

Tableau 1

Valeurs moyennes du débit hématique cérébral en ml/100 g/min

	$\bar{f}$	f_1	f_2	hH/hC
1. Normaux (10 sujets)	52.5 ± 3.8	70.7 ± 6.6	18.9 ± 5.9	3.30 ± 0.77
2. Thrombose carotide interne (DHC controlatéral)	36.1 ± 12.3	55.3 ± 8.4	12.1 ± 2.4	1.45 ± 0.30
3. Lésions ischémiques				
A) DHC homolatéral	38.8 ± 13.2	69.1 ± 19.5	19.1 ± 8.9	3.68 ± 1.08
B) DHC controlatéral	38.2 ± 11.5	72.1 ± 16.8	20.4 ± 8.3	3.14 ± 1.25

phantome (un crâne sec) dans lequel un hémisphère cérébral était constitué de paraffine et l'autre de ^{133}Xe en solution aqueuse, de cette façon nous avons mésuré l'interaction avec le crystal des rayons gamma venant du coté opposé et nous avons calculé un rapport de 2,67 entre la hauteur des courbes enregistrées des deux cotés dans le même temps. Cette valeur était en accord avec les déterminations cliniques dans les sujets sains et nous a conduit à considérer les valeurs *inférieures à 2,60 comme témoins* de passage de traceur radioactif vers l'hémisphère controlatéral à l'injection.

A l'egard du groupe témoin le débit moyen $\bar{f}$ est reduit (Tableau 1) chez tous les malades, tandis que les composantes, rapide f_1 et lente f_2, sont très réduites seulement dans le groupe des thromboses de l'artère carotide interne ; pratiquement elles ne sont pas modifiées dans les autres groupes. Il faut aussi remarquer que le rapport hH/hC est surement baissé en cas de thrombose de la carotide interne.

Tous les résultats du debit hematique cérébral ont été comparés avec les resultats de l'examen neuropsychique, de l'évolution et des données des examens angiographiques et electroencéphalographiques (Tableaux 2, 3, 4) ; les corrélations ont eté etudiées avec la methode des regressions multiples au moyen du calculateur IBM 7040.

Les correlations entre le débit hematique cérebral dans l'hémisphère homolatéral a la lesion et les données cliniques sont illustrees dans le Tableau 2, dans lequel paraissent seulement les correlations significatives; on ne doit pas s'étonner du fait que la variance expliquee par les variations du débit ne parvient pas a un pourcentage tres haut: en effet le débit hématique cerébral est seulement un parmi plusieurs facteurs qui determinent la situation clinique. Entre les données les plus significatives nous voulons souligner la valeur du $\bar{f}$ homolatéral qu'avec le 80 % de probabilité rend raison de 33 % de la variance observee dans le complexe 'examen neuropsychique + evolution', du meme

Tableau 2

Corrélations entre debit hématique cérébral homolateral et données cliniques

	Probab l té	Variance expliquée
1 $\bar{f}$ → Examen neuropsych que + évolution	80	33 °
2 $\bar{f}$ → Évolution	90	20
3 f → Examen neuropsych que + évolution	80	28
4 f → Examen neuropsychique	80	21 °

Tableau 3

Corrélations entre debit hematique cérébral controlateral et données cliniques

	Probabilité	Variance expliquée
1 $\bar{f}$ → Examen neuropsychique + évolution	95	41
2 $\bar{f}$ → Évolution	99 /	36
3 f → Évolution	90	9
4 hH/hC → Évolut on	90	9

Tableau 4

Correlations entre debit hématique cérébral et examens arteriographiques et EEG

	Prob bilité	Variance expl quée
1 f homolatéral → Artériograph e	80	16
2 f homolatéral → Artér ographie	0	0
3 f controlatéral → Artériographie	<80	6
4 f controlatéral → Arteriograph e	80 /	6 9
5 f homolatéral → EEG	80 /	11
6 hH/hC → Artériograph e	99 /	38 °

ordre sont les correlations entre $\bar{f}$ et l evolution f_1 et examen neuropsychique + évolution et enfin entre f_1 et examen neuropsychique

Pour le debit hématique cerebral controlateral on a observé les correlations plus étroites entre $\bar{f}$ et examen neuropsychique + évolution et $\bar{f}$ et l evolution toute seule Il y a des correlations bien plus faibles entre f_1 et l evolution et aussi entre hH/hC et l évolution

Parmi les corrélations entre le débit et les données angiographiques et elec troencephalographiques on releve les plus significatives entre f_1 homolateral

Tableau 5

		Valeurs de hH/hC
1	Phantome	2 67
2	Normal	3 30 ± 0 77
3	*Thrombose carotide interne (débit hématique cérébral) controlateral*	1 45 ± 0 30

et angiographie et surtout entre hH/hC et angiographie ou avec le 99 % de probabilité est expliqué le 38 % de la variance observée

D'après ce que nous avons exposé jusqu'ici on peut dire que tous les malades avec lésions cérébrovasculaires à foyer ischémique présentent une réduction du $\bar{f}$ *soit dans l'hémisphère* atteint soit dans la controlatérale, pour cette dernière la réduction probablement est en rélation avec la diffusion des lésions artériosclérotiques sans exclure la possibilité de phénomènes de dépression transhémisphérique

En particulier les valeurs de $\bar{f}$, f_1 et f_2 controlatérales sont réduites dans les cas de thrombose de l'artère carotide interne ces résultats et la réduction du rapport hH/hC témoignent d'un important passage de sang vers l'hémisphère atteint *En effet* dans les cas de thrombose de l'artère carotide interne avec *suppléance* controlatérale demontrée par l'artériographie le rapport a été toujours au dessous de 2,0 confirmant notre interprétation des données du debit hématique cérébral dans ces cas

Du point de vue clinique on retrouve les corrélations les plus significatives entre $\bar{f}$, les données de l'examen neuropsychique et l'évolution et dans le cas de déterminations controlatérales (Tableau 3) ces résultats confirment la globalité des lésions artériosclérotiques

Les débits de la substance grise et blanche sont bien corrélés avec les données de l'examen neuropsychique et l'évolution, mais seulement dans les déterminations homolatérales (Tableau 2)

Les valeurs du débit homolatéral de la substance grise rendent raison aussi des données angiographiques et électroencephalographiques, mais avec un pourcentage de variance expliquée moindre de 20 %

Enfin l'importance du rapport hH/hC dans l'évaluation de la circulation collatérale de suppléance est soulignée par la corrélation tres étroite entre la valeur de l'index et les données angiographiques (Tableau 4)

En conclusion il nous semble que la détermination du débit hématique cérébral chez les malades atteints de lésions cérébrovasculaires à foyer ischémique soit utile non seulement pour mieux comprendre les méchanismes pathogénétiques mais aussi pour une évaluation plus objective du prognostic

Remerciement

Nous remercions le Professeur Ricci Directeur du Centre de Calcul de l Université de Milan pour nous avoir permis l emploi du calculateur IBM 7040

RÉSUMÉ

Les auteurs on étudié le débit hématique cérébral chez un group de sujets atteints des lésions cérébrovasculaires a foyer ischémique et chez un groupe témoin En particulier ils ont analysé les courbes de dépuration du ^{133}Xe introduit dans l artère carotide interne calculant les valeurs du débit hématique moyen de ses deux composantes rapide et lente du poids relatif a la substance blanche et du rapport hH/hC entre la hauteur de la courbe homolatérale a l injection et la hauteur de la courbe controlatérale Sur la base de ces valeurs obtenues d apres 70 déformations du débit hématique cérébral les auteurs ont établi des corrélations avec les données cliniques électroencéphalographiques et surtout angiographiques ayant trait aux mêmes malades examinés sous le profil du débit hématique

SUMMARY

An investigation was made of the cerebral blood flow in a group of patients with ischemic cerebrovascular disease and in a control group The curves obtained after injection of ^{133}Xe into the internal carotid artery were analyzed and a comparison was made between the mean cerebral blood flow its rapid and slow components the relative weight of the white matter the relationship hH/hC and the shapes of the curves obtained for the two sides The values obtained in 70 investigations of the cerebral blood flow were correlated with the clinical electroencephalographic and in particular with the angiographic findings

ZUSAMMENFASSUNG

Die cerebrale Durchblutung bei Patienten mit ischämischen cerebrovaskularen Erkrankungen und einer Kontrollgruppe wurde untersucht Analysen der Kurven nach Injektion von ^{133}Xe in die A carotis interna wurden vorgenommen wobei die durchschnittliche cerebrale Durchblutung die raschen und langsamen Komponenten das relative Gewicht der weissen Hirnsubstanz und das Verhaltnis von hH/hC und die Amplitude der Kurven verlaufe der einen Seite verglichen mit denen der anderen Seite studiert wurden Die Werte der cerebralen Durchblutung von 70 Untersuchungen wurden zu den klinischen elektroencephalographischen und besonders den angiographischen Befunden in Beziehung gestellt

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et angiographie et surtout entre hH/hC et angiographie ou avec le 99 % de probabilite est expliqué le 38 % de la variance observee

D apres ce que nous avons expose jusqu'ici on peut dire que tous les malades avec lésions cérebrovasculaires a foyer ischémique presentent une reduction du $\bar{f}$ soit dans l'hemisphere atteint soit dans la controlaterale , pour cette derniere la réduction probablement est en relation avec la diffusion des lesions artériosclerotiques sans exclure la possibilite de phenomenes de depression transhemispherique

En particulier les valeurs de $\bar{f}$, f_1 et f controlatérales sont reduites dans les cas de thrombose de l artere carotide interne ces resultats et la reduction du rapport hH/hC témoignent d un important passage de sang vers l hémi sphere atteint En effet dans les cas de thrombose de l'artere carotide interne avec suppléance controlatérale demontree par l artériographie le rapport a éte toujours au dessous de 2,0 confirmant notre interprétation des données du débit hematique cérébral dans ces cas

Du point de vue clinique on retrouve les correlations les plus significatives entre $\bar{f}$, les donnees de l examen neuropsychique et l'evolution et dans le cas de determinations controlaterales (Tableau 3) ces resultats confirment la globalite des lesions arteriosclerotiques

Les débits de la substance grise et blanche sont bien corréles avec les donnees de l examen neuropsychique et l evolution, mais seulement dans les deter minations homolaterales (Tableau 2)

Les valeurs du debit homolateral de la substance grise rendent raison aussi des données angiographiques et electroencéphalographiques, mais avec un pourcentage de variance expliquee moindre de 20 %

Enfin l'importance du rapport hH/hC dans l'evaluation de la circulation collaterale de suppleance est soulignee par la correlation tres etroite entre la valeur de l'index et les donnees angiographiques (Tableau 4)

En conclusion il nous semble que la determination du debit hématique cerebral chez les malades atteints de lesions cerebrovasculaires a foyer ische mique soit utile non seulement pour mieux comprendre les mechanismes pathogenetiques mais aussi pour une evaluation plus objective du prognostic

FROM THE DEPARTMENTS OF DIAGNOSTIC RADIOLOGY (DIRECTOR H LODIN) AND NEUROSURGERY (DIRECTOR E BOHM), THE UNIVERSITY HOSPITAL, UPPSALA, SWEDEN

EFFECT OF CAROTID AND VERTEBRAL ANGIOGRAPHY ON THE CEREBRAL CIRCULATION STUDIED WITH INTRAVENOUS ISOTOPES

Preliminary report

by

K Bergstrom, E Bohm, A Ivarsson and H Lodin

It is recognized that cerebral angiography may cause impairment of the clinical condition although no precise information seems to be readily available The authors therefore believe that a report on a study of the cerebral circulation with intravenous isotopes before and after angiography might be of interest

Material and Method The material consisted of 18 patients with subarachnoid hemorrhage, sixteen of whom were examined with carotid and two with vertebral angiography

Direct puncture of the internal or common carotid artery was performed, and 6 to 8 ml Urografin 60 % were automatically injected in each series There were no intramural injections Vertebral angiography was carried out by the catheter technique, with the tip in the vertebral or the subclavian artery A film changer was used, and ECG and exposures were recorded All the examinations were performed without a general anaesthetic The radiologic determination of the circulation time in the first series of angiograms was calculated, according to the method of Greitz (1956), as the time between the maximum concentration in the carotid siphon and the parietal veins

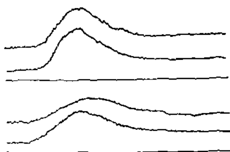


Fig 1 Indicator dilution curves of a normal subject (upper curves) and of a patient with recent subarachnoid bleeding (lower curves)

Isotope technique The cerebral circulation was examined prior to and 2 hours following angiography and then 24 hours later with a radioactive indicator dilution technique (OLDENDORF & KITANO 1965, BOHM et coll 1968) Iodine 131 labelled para aminohippuric acid was injected intravenously with a gamma detector located on each side of the head The mean transit time expressed in seconds and the cerebral blood flow in counts per second were calculated

Results and Discussion

All figures and tables are based on the material of carotid angiographies

Indicator dilution curves of a normal subject and of a patient with recent bleeding from a cerebral aneurysm are presented in Fig 1 It may be noted that the time lapse is prolonged in the patient with subarachnoid hemorrhage and that the height of the curves is less in comparison with those of the normal subject

The cerebral blood flow and mean transit time were studied in a group of normal subjects the values being collected in Fig 2 where they appear within the rectangle Fig 2 also reveals reduction in the cerebral blood flow after carotid angiography in a patient with bleeding The test one day after angiography disclosed a return to almost pre angiographic values however

Fig 3 indicates the relationship in 16 patients between the circulation time measured during serial angiography and the mean transit time calculated from the indicator dilution curve The correlation is fairly good

The relationship between the test values (pre angiographic and those obtained 2 hours after angiography) and the clinical condition in 16 of the patients is presented in Table 1 One group consists of patients in good clinical condition An intermediate group had cervical stiffness and a third group displayed drowsiness and disorientation

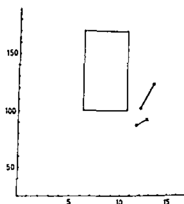


Fig 2 Cerebral blood flow in counts per second (ordinate) and the mean transit time in seconds (abscissa) in a group of normal subjects the values fall within the rectangle The values in a patient with subarachnoid hemorrhage are also given before angiography (full line) *2 hours after angiography (dashes) and 24 hours after* angiography (dots) Circles indicate the side examined and crosses the other side

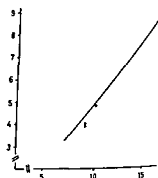


Fig 3 Relationship between circulation in seconds measured during serial angiography (ordinate) and the mean transit time calculated from the indicator dilution curve (abscissa)

The first group had higher pre angiographic values for the cerebral blood flow and a shorter mean transit time than the third group The results from the test 2 hours after angiography, especially the cerebral blood flow, indicated that *impairment was greater in the third group* Also the intermediate group showed some impairment, especially in the mean transit time It was rather puzzling that in the group of patients in good clinical condition there were two who showed a decrease in cerebral blood flow, these patients had one feature in common, however angiography was performed with difficulty and three punctures had to be made into the carotid artery Only in patients of the third group was clinical impairment *observed after angiography The isotope* values at the 24 hour test had returned to the pre angiographic level

The influence of angiography on the cerebral blood flow in the sixteen patients is apparent from Table 2 There were eight patients with increased values on both sides, five of whom were in good clinical condition and three of whom had cervical stiffness, and there were eight patients with reduced values on both sides These last eight patients were made up of two in good *clinical* condition but with puncture difficulties, one with cervical stiffness and five patients in poor clinical condition The difference in cerebral blood flow between the angio

Table 1

Relationship between clinical condition and test values

Clinical condition	Before angiography		Two hours after angiography		Days after bleeding or operation	Clinical condition after angiography
	Cerebral blood flow counts/second	Mean transit time seconds	Decrease of cerebral blood flow counts/second	Prolongation of mean transit time seconds		
Good	113	8 4	29	0 3	10	No impairment
	108	7 3	0	0 2	38	
	140	8 9	60	0	8	
	93	9 1	0	0 6	13	
	104	7 5	0	0	6	
	125	9 9	0	0	8	
	49	8 8	0	0 9	32	
Cervical stiffness	77	8 5	0	1 9	5	No impairment
	89	11 1	0	0	1	
	61	12 6	0	2 6	5	
	96	9 8	48	9 6	17	
Drowsiness and disorientation	103	12 0	42	0	11	Impairment
	89	12 4	17	0 6	4	
	88	14 1	30	4 7	4	
	81	16 7	13	0	6	
	106	14 2	41	0	2	

graphic and the other side was small but presented a constant tendency in the two groups

The influence of carotid angiography on the mean transit time (Table 3) was bilateral shortening in six patients bilateral prolongation in seven and shortening on one side and prolongation on the other side in three patients The prolongation was unassociated with the clinical condition but was least in the group in good clinical condition

A temporary improvement in the cerebral blood flow occurred in the two patients subjected to vertebral angiography

Comparison with a group of thoracic aortographies to study the influence of puncture was planned The results were however difficult to evaluate in six such patients with manifest heart disease although a slight impairment in the cerebral circulation was apparent The authors have therefore started a series of carotid angiographies with a catheter technique after femoral catheterization

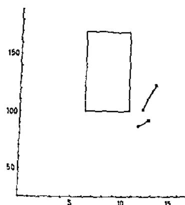


Fig. 2. Cerebral blood flow in counts per second (ordinate) and the mean transit time in seconds (abscissa) in a group of normal subjects; the values fall within the rectangle. The values in a patient with subarachnoid hemorrhage are also given before angiography (full line), 2 hours after angiography (dashes) and 24 hours after angiography (dots). Circles indicate the side examined and crosses the other side.

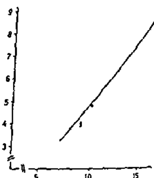


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Table 2

Influence of carotid angiography on cerebral blood flow

Change in blood flow	Number of patients	Difference in cerebral blood flow in counts/second average	
		Angiographic side	Other side
Increase on both sides	8	+17	+20
Decrease on both sides	8	—35	—30

Table 3

Influence of carotid angiography on mean transit time

Change in mean transit time	Number of patients	Difference in mean transit time in seconds average	
		Angiographic side	Other side
Shortening on both sides	6	—1.3	—1.8
Prolongation on both sides	7	+3.2	+2.0
Shortening on one side and prolongation on the other	3	+0.7	—0.5

Conclusions

The mean transit time as determined with an intravenous isotope technique correlates fairly well with the circulation time measured in serial angiography. The investigation suggests that in patients with subarachnoid hemorrhage but in good clinical condition the contrast medium may apparently produce dilatation which lasts longer than previously recognized. All the patients in poor clinical condition, as well as two patients in good clinical condition but in whom there was trouble with the injection, exhibited a reduction in the cerebral blood flow. It is impossible from this preliminary investigation, however, to proportion the degree of influence from the puncture and the contrast medium. Further studies are planned.

SUMMARY

The cerebral blood flow was studied by an indicator dilution method with intravenous injection of ^{131}I labelled PAH before and after cerebral angiography in a group of patients with subarachnoid hemorrhage. A reduction in the cerebral blood flow after angiography was observed in all patients in poor clinical condition.

ZUSAMMENFASSUNG

Die cerebrale Blutzufuhr in einer Gruppe von Patienten mit Subarachnoidalblutung wurde mittels einer Verdunnungsindikator Methode nach der intravenosen Injektion von mit ^{131}J markierten PAH vor und nach cerebraler Angiographie gemessen Bei allen Patienten im schlechten Allgemeinzustand lag eine verminderte Blutzufuhr vor

RÉSUMÉ

Le debit sanguin cerebral a eté etudie par une methode de dilution par injection intra veineuse de PAH marquee a l iode 131 avant et apres angiographie cerébrale sur un groupe de patients atteints d hemorragie sous-arachnoidienne Les auteurs ont constate une reduction du debit sanguin cerebral apres l angiographie chez tous les malades qui etaient dans un mauvais etat clinique

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AUS DEM INSTITUT FÜR KLINISCHE STRAHLENKUNDE (DIRECTOR PROF J DIETHELM) UND DER NEUROCHIRURGISCHEN KLINIK (DIREKTOR PROF K SCHÜRMANN) DER JOHANNES GUTENBERG-UNIVERSITÄT, MAINZ, DEUTSCHLAND

GEHIRNSZINTIGRAPHIE MIT RADIOAKTIVEM MAKROAGGREGIERTEM ALBUMIN UND ^{99m}Tc PERTECHNETAT

Vergleich der Ergebnisse

von

J P HAAS, H DIETZ und R WOLF

Mit der intraarteriellen Injektion von radioaktivem makroaggregiertem Albumin definierter Partikelgrösse ist es möglich geworden die arterielle Strombahn szintigraphisch darzustellen Die Partikel bleiben sozusagen als strahlende Mikroembolie in den arteriellen Kapillaren hängen Tierversuche von TAPLIN u Mitarb (1964) an Hunden, von KENNADY u Mitarb (1965, 1966, 1967) und von KING u Mitarb (1966) an Mäusen haben die Ungefährlichkeit der Injektion in zerebrale Arterien bewiesen Günstige klinische Berichte stammen von ROSENTHALL u Mitarb (1965, 1966), DOERING u Mitarb (1966, 1967) JOSEPH u Mitarb (1967), KANEKO u Mitarb (1967), DIETZ u Mitarb (1967) und HAAS u Mitarb (1966, 1967)

Wir haben bis jetzt 60 Patienten mit dem neuen Verfahren untersucht Kurz vor Beendigung einer Carotis- bzw Vertebralis Angiographie in Vollnarkose wurden 150 µCi ^{131}J makroaggregiertes Albumin intraarteriell durch die liegende Nadel bzw den Katheter injiziert Die Szintigraphie wurde im Laufe der folgen

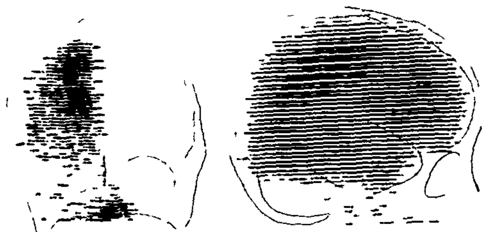


Abb. 1. Normales Szintigramm in Rucken- und linker Seitenlage nach Injektion von 150 μCi ^{131}J MAA in die rechte Arteria carotis

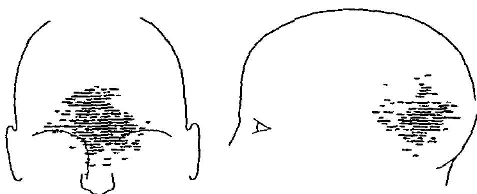


Abb. 2. Normales Szintigramm in Rucken- und rechter Seitenlage nach Injektion von 150 μCi ^{131}J MAA in eine Arteria vertebralis

den zwei Stunden in Seiten- und Rückenlage vorgenommen. Bei keinem unserer untersuchten Patienten traten irgendwelche Reaktionen oder Nebenerscheinungen auf, die der Injektion der Albuminpartikel hätte zugeschrieben werden konnen. Bei den von uns untersuchten Fallen handelte es sich um 42 intrakranielle Tumoren und 18 Falle mit Gefassprozessen. Von den Tumoren waren 21 Gliome, 9 Rezidiv-Gliome, 3 Glioblastome, 5 Meningiome, 3 Metastasen, 2 Kraniopharyngeome und 3 Kleinhirnbruckenwinkeltumoren. Die Gefasskrankheiten waren zwei generalisierte Gefassprozesse, ein Media- und ein Interna-Verschluss

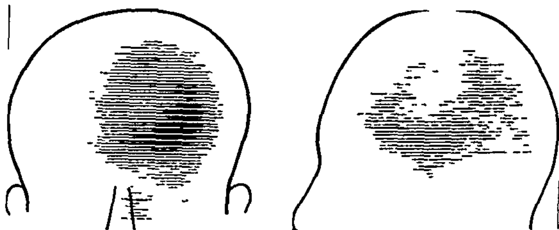


Abb 3 Aktivitatsaussparung frontal prazentral links nach Injektion von 150 μCi ^{131}J MAA in die linke Arteria carotis Operativ gesichertes rasch wachsendes Gliom ohne starkere Vaskularisation mit ^{99m}Tc Pertechnetat intravenos Aktivitatsanreicherung

vier arteriovenose Angiome, drei chronisch subdurale Hamatome, ein Abszess und eine Enzephalitis, die wegen Tumorverdacht untersucht wurden, und funf stenosierende Gefassprozesse

Nach Injektion von ^{131}J makroaggregiertem Albumin in eine Arteria carotis lasst sich die betreffende Grosshirnhalfte szintigraphisch darstellen (Abb 1), nach Injektion in eine Arteria vertebralis beider Kleinhirne (Abb 2) Je nach den vorliegenden anatomischen Variationen oder veranderten Stromungsverhaltnissen kann es auch zur Darstellung weiterer Gefassprovinzen kommen Wird das Gebiet der Arteria pericallosa der injizierten Seite von der Gegenseite versorgt, so kommt es zu einer Aktivitatsaussparung auf der injizierten Seite, die auf dem Szintigramm in Ruckenlage keilformig paramedian, in Seitenlage frontal prazentral zu erkennen ist Wird umgekehrt die Arteria pericallosa der nicht injizierten von der injizierten Seite versorgt, so erkennt man auf dem Szintigramm in Ruckenlage eine uber die Mittellinie hinausgehende paramediane keilformige Aktivitatsanreicherung Auf dem Szintigramm in Seitenlage lasst sich diese durch Uberlagerung von der injizierten Seite her nicht erkennen Nach Injektion in die Arteria vertebralis kann es bei entsprechenden Stromungsverhaltnissen zu einer etwas kraftigeren Anreicherung in einer Kleinhirnhalfte kommen, was in Ruckenlage zur Darstellung kommt Beim seitlichen Szintigramm ist die Darstellung der weiter ventral gelegen Hirnanteile davon abhangig, ob die Arteriae posteriores vom Vertebralis- oder vom Carotiskreislauf versorgt werden In letzterem Falle kommt es nur zur Darstellung der Kleinhirne Beim vollstandigen Verschluss einer Arteria carotis kann es durch Stromungsumkehr uber Anastomosen zwischen beiden Gehirnhalften bei der Injektion in die gegenseitige

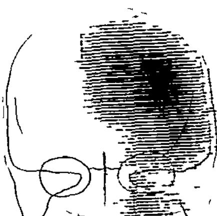


Abb 4 Aktivitatsaussparung basal von der Mittellinie ausgehend und nach links reichend nach Injektion von 150 μCi ^{131}J MAA in die linke Arteria carotis. Operativ gesichertes Kraniopharyngeom mit ^{99m}Tc Pertechnetat intravenos Aktivitatsanreicherung

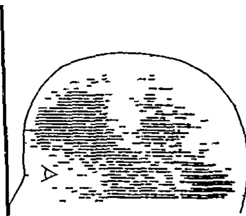


Abb 5 Aktivitatsaussparung links temporal nach Injektion von 150 μCi ^{131}J MAA in die linke Arteria carotis Grosses arteriovenoses Angiom operativ bestatigt mit ^{99m}Tc Pertechnetat intravenos Aktivitatsanreicherung

Arterie auch zu einer szintigraphischen Darstellung der nicht injizierten arteriell verschlossenen Seite kommen

Bei der Gehirnszintigraphie nach intravenoser Injektion eines Tracers z B von ^{99m}Tc Pertechnetat stellt sich infolge Storung der Bluthirnschranke der pathologische Prozess immer als Aktivitatsanreicherung dar Im Gegensatz dazu kann es bei der intraarteriellen Injektion von ^{131}J makroaggregiertem Albumin entweder zu einer Anreicherung oder Aussparung der Aktivitat kommen Die Aktivitatsaussparung ist Ausdruck einer fehlenden Einlagerung des radioaktiv markierten makroaggregierten Albumins Hierfur gibt es folgende Moglichkeiten fehlende Passage infolge verminderter Durchblutung oder Umleitung durch arteriovenose Anastomosen oder zu schnelle Passage infolge Weitstellung von Gefassen Fehlende Passage des ^{131}J makroaggregierten Albumins infolge Drosselung der Durchblutung kann ihre Ursache in einer Raumforderung haben

1 Bei zystischen Tumoren Abszessen sklerosierenden Prozessen Rezidivtumoren Tumoren mit starkerer odematoser Randzone wie Metastasen und rasch wachsenden Gliomen (Abb 3) ohne starkere Vaskularisation

2 Bei extrazerebralen Tumoren als Ausdruck eines verdrangenden Tumorwachstums wie Meningiomen oder basalen Tumoren, wie Kraniopharyngeomen (Abb 4)

3 Bei obliterierenden Gefassprozessen, wie Gefass-Sklerose die zur Stenose fuhrt oder Gefassverschluss

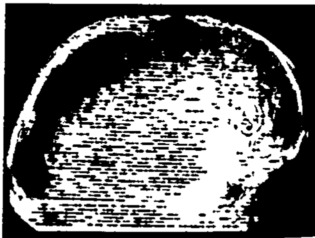


Abb. 6. Aktivitätsanreicherung rechts temporal nach Injektion von 150 µCi ^{131}J MAA in die rechte Arteria carotis. Malignes Astrozytom, stark vaskularisiert, jedoch ohne arteriovenöse Kurzschlüsse (operativ bestätigt). Mit ^{99m}Tc Pertechnetat intravenös Aktivitätsanreicherung

Fehlende Passage infolge Umleitung durch arteriovenöse Anastomosen oder zu schnelle Passage durch Weitstellung von Gefässen finden wir in Angiomen (Abb. 5) oder in gefässreichen Tumoren wie Glioblastomen.

Aktivitätsanreicherungen sind Ausdruck eines verstärkten Festhaltens des ^{131}J makroaggregierten Albumins innerhalb des Gefässbettes. Wir finden sie (1) bei engmaschigem Gefässnetz, (2) bei starker Vaskularisation ohne arteriovenöse Kurzschlüsse, (3) bei fehlender zystischer Degeneration oder geweblicher Sklerose, und (4) beim Fehlen einer stärkeren kollateralen Ödemzone.

Ein malignes Astrozytom temporal, das sich bei der Operation als stark vaskularisiert herausstellte, nach der Angiographie jedoch ohne sichere arteriovenöse Kurzschlüsse, wird als Beispiel in Abb. 6 gezeigt. Ausserdem fehlte das Ödem bzw. eine zystische Degeneration oder Sklerose. Die Szintigraphie mit ^{99m}Tc Pertechnetat zeigte auch eine gute Anreicherung der Aktivität im Tumor.

Der Vergleich der intraarteriellen ^{131}J MAA Szintigraphie mit der intravenösen ^{99m}Tc Pertechnetat Szintigraphie zeigt, dass beide Methoden zumindest ebenbürtig, was die zirkulatorischen Verhältnisse und die Artdiagnose betrifft, erstere der letzteren sogar überlegen ist. Wir möchten die relativ neue Methode jedoch durchaus nur im Zusammenhang mit den anderen erprobten neuroradiologischen Methoden angewandt und betrachtet wissen. Nur so wird sie ihre ganze Leistungsfähigkeit entfalten können.

ZUSAMMENFASSUNG

Gehirnszintigraphie mit direkter Injektion in Gehirnarterien von ^{131}J makroaggregiertem Albumin wurde in 60 Patienten ohne Komplikationen vorgenommen. Bei 42 Patienten lag ein Gehirntumor, bei 18 ein Hirngefässprozess vor. Bei fast allen Patienten wurde ausserdem

ein Szintigramm mit ^{99m}Tc Pertechnetat durchgeführt Im Vergleich dazu brachte die Szintigraphie nach intraarterieller Injektion von ^{131}J makroaggregiertem Albumin zum Teil weitergehende Informationen

SUMMARY

Brain scintigraphy with direct cerebrovascular injection of ^{131}I macro-aggregated albumin was performed without complications in 60 patients Of these 42 had a brain tumour and 18 cerebrovascular disease In almost all of the patients a scintigram with ^{99m}Tc pertechnetate was also obtained In comparison with the latter procedure it was found that in some respects more information could be derived from scintigraphy after intra arterial injection of ^{131}I macro-aggregated albumin

RÉSUMÉ

Les auteurs ont fait des scintigraphies cerebrales sur 60 malades sans complication par injection directe dans les arteres du cerveau de macro-agregats d albumine marquee par ^{131}I Quarante-deux malades avaient une tumeur cerebrale et dix huit avaient une affection vasculaire cerebrale Les auteurs ont fait aussi a presque tous ces malades une scintigraphie par le pertechnetate au ^{99m}Tc La scintigraphie par injection intra arterielle de macro-agre ats d albumine marquee par $^{1\ 1}$I fournit dans une certaine mesure des informations plus completes

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FROM THE DEPARTMENT OF RADIOLOGY, COLLEGE OF PHYSICIANS AND SURGEONS
COLUMBIA UNIVERSITY, NEW YORK N Y U S A

REGIONAL CEREBRAL PERFUSION WITH THE IMAGE INTENSIFIER CAMERA

Preliminary studies

by

PHILIP M JOHNSON SADEK K HILAL GERALD S FREEDMAN, JAMES A REILLY
and ERNEST H WOOD

At its inception the automatic mapping of radioactivity distributions in body organs was accomplished by rectilinear scanning In this procedure a collimated radiation detector mechanically tracked in small increments over the area of interest, producing a display of detected photons by various analogue techniques. Since a finite time interval was required to complete the mapping the concentration of radioactivity in the target organ could not vary significantly during this period without adversely affecting the information content of the scan Rectilinear scanning is therefore synonymous with static mappings of organs or structures in which the level of radioactivity was reasonably constant It cannot record dynamic events such as the rapid influx of an intra arterial radioactive indicator into and out of the brain

This limitation was overcome with the development of stationary imaging systems that could survey an entire area of interest and rapidly display the radioactive events detected therein These scintillation cameras comprise the second generation of organ imaging devices They may well supplant rectilinear scanning systems since they can record both static and dynamic events

Until recently there were two types of scintillation imaging systems. The earlier and more widely used is the ANGER (1957) gamma camera, in which an array of phototubes records radioactive events occurring in a broad thin scintillation crystal Subsequently the crystal mosaic camera or autofluoroscope was devel

oped independently by BENDER & BLAU (1963) and by GROSS et coll (1964) In 1967 a third type of scintillation imaging system, the image intensifier camera designed by TER POGOSSIAN (1963), became available for clinical trial

The image intensifier camera has several components Radioactive events are detected in a thin, curved cesium iodide scintillation crystal (diameter 22 cm) situated behind a multiple parallel channel collimator Both coarse and fine collimators are available The inner crystal surface faces an image intensifier tube similar to those used in cineradiography, but with higher gain A greatly amplified display of scintillations resulting from interaction of roentgen or gamma photons in the crystal is generated on the image tube's output phosphor This is viewed by an orthicon television camera, whose signal is instantaneously displayed on a television monitor and simultaneously recorded on magnetic (video) tape at the rate of 60 frames per second Time signals can be imprinted on the tape by an audio system From video tape storage, data are selectively retrieved for redisplay on the television monitor and an oscilloscope screen This display may then be recorded by still or cine photography The present capabilities of the data retrieval system permit photographic recording of radioactive events during intervals of any desired length to a minimum of 1/60 second, although it is impractical to analyze data acquisition in intervals shorter than 1/10 second Image display is analogue in nature and data quality is predetermined by the parameters selected for recording Digital information cannot readily be obtained and stored data cannot be modulated

Photon detection capability of the image intensifier camera is maximal at photon energies of about 80 keV, thus, the camera is particularly suited for xenon 133 and mercury 197, but it also produces satisfactory images with iodine 125 (35 keV) and technetium 99m (140 keV) A sharp decrement of detection efficiency above the 175—200 keV energy range precludes use of indium 113m and other nuclides of similar or higher photon energies

This report presents our initial results in applying the image intensifier camera to study of regional cerebral perfusion in health and in disease

Materials and Methods The radiopharmaceuticals used in these investigations were ^{99m}Tc as pertechnetate, eluted daily in sterile isotonic saline from a sterile ^{99}Mo—^{99m}Tc generator, and ^{133}Xe dissolved in sterile isotonic saline

The image intensifier camera was adjusted for the radioisotope to be administered by setting the beam and orthicon television voltage readings to predetermined values prior to each recording sequence Initially, control factors selected for scintillation imaging were not changed during a recording sequence However, occasional flaring of the image due to saturation of the orthicon during the period of peak radioactivity proved unacceptable and could not sub

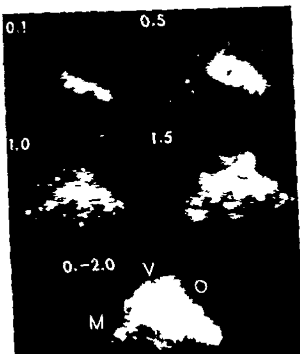


Fig 1 Cephalic perfusion in the dog lateral projection Xenon 133 was injected into the common carotid artery during occlusion of the external carotid artery Bottommost scintigram was exposed for 2 seconds after injection and the others for 0 1 seconds at 0 1 0 5 1 0 and 1 5 seconds after injection
V—vertex O—occiput M—muzzle

sequently be eliminated from the recorded image It therefore became our practice to adjust the beam setting whenever the television monitor indicated an incipient image flare All detected radioactive events were stored on video tape together with imprinted audio time signals Images of radioisotope distributions accumulated during selected time intervals of 0 1—5 0 *seconds* were displayed by tape playback and photographed on fast polaroid *film*

Dogs weighing 20 to 60 kg were obtained from the *Institute of* Comparative Medicine after immunization and deworming Following induction of anesthesia by intravenous nembutal and endotracheal *intubation*, the common carotid artery was exposed in the neck A teflon *(R) catheter* was advanced into this artery and a ligature was placed about *the latter to* secure the catheter Periodic flushes with physiologic saline and *injection* of heparin maintained catheter patency Before intracarotid *administration* of the radiopharmaceutical the camera was positioned against the *ipsilateral* side of the head Cranial perfusion by carotid blood was monitored by *television* and stored *on tape* Each animal was deeply anesthetized during investigation



Fig 2 Continuation of study in fig 1 Each scintigram was exposed for 2 seconds and each exposure ended at the indicated time in seconds after injection This method of noting time of exposure is also followed in subsequent figures

Clinical investigations

Studies of cephalic perfusion by intravenously administered radioisotopes With the patient supine the camera was placed over the bregma so that its central axis was parallel to the sagittal plane, forming a 20° angle with Reid's baseline (This position was somewhat similar to that of the roentgen tube in a Townes projection of the skull) Radioactive landmarks were taped at the outer canthi A high specific activity solution of pertechnetate, 10 mCi, was injected as rapidly as possible into an antecubital vein Scintillation imaging of cephalic radioactivity was carried out for 1 minute

Studies of cerebral perfusion by arterially administered radioisotopes Arterial perfusion studies were performed immediately upon completion of carotid or aortic arch angiography Either ^{133}Xe dissolved in saline or ^{99m}Tc pertechnetate were administered via the needle or catheter employed in the angiographic procedure The camera was positioned as described above for frontal scintillation imaging and against the ipsilateral aspect of the head, with central axis normal to the sagittal plane, for lateral imaging Radioactive landmarks were taped at the outer canthi or on Reid s baseline according to the projection employed for imaging



Fig 3 Enlarged 1 second scintigrams of a 63 year-old male 3 seconds after injection of ^{99m}Tc pertechnetate into the right internal carotid artery This patient's carotid arteriogram was normal a) Lateral scintigram showing uniform cerebral distribution of radioactivity Radioactive marker at outer canthus is indicated by the longer arrow The marker at the external auditory (indicated by shorter arrow) is not visible on reproduction b) Anterior scintigram showing uniform diffusion of tracer in the right hemisphere with crossover into the left hemisphere White line joins radioactive markers at outer canthi

Results

The initial studies in the dog established the utility of the image intensifier camera in displaying the entry, distribution and clearance of the injected tracer Xenon 133 dissolved in saline was used in these studies This chemically inert gas diffuses freely into the cerebral parenchyma thereafter its efflux is a function of blood flow A typical sequence is displayed in Figs 1 and 2 in which serial lateral scintigrams of the canine head were recorded after injecting xenon 133 into the common carotid artery during occlusion of the external carotid artery The rapidly changing events comprising the arrival and early intracranial diffusion of the radioactive indicator can be differentiated by the stop motion capability of the camera system The topmost four scintigrams in Fig 1 represent exposures of 0 1 second duration obtained at the indicated intervals after injection The lowest scintigram exposed for 2 0 seconds has integrated all radioactive events occurring between zero and 2 0 seconds after injection The diffuse perfusion of ^{133}Xe with entry into the external carotid system via the large



Fig 4 Serial anterior 1 second scintigrams of a 31 year old female after injection of ^{99m}Tc pertechnetate into the left internal carotid artery This patient s carotid arteriogram was normal A questionable left parasagittal perfusion deficit is shown on the early images The pericallosal arteries and later the superior sagittal sinus account for the vertical midline radioactivity The internal jugular veins particularly the right are outlined at 4—6 seconds

collaterals characterizing this species, produces a recognizable image of the dog s head

In Fig 2, a continuation of Fig 1, serial 2 second scintigrams were made during the 3rd through 28th seconds after injection These images are more uniform than the irregular, noisy displays of the 0 1 second scintigrams owing to the greater number of photons collected during the longer observation time There is a gradual diminution of radioactivity in the head as a function of time, a finding consistent with the known pattern of clearance of xenon from the brain as measured by external detectors (MALLET & VEALL 1965)

Having established in animals the various technical parameters for demonstration of cerebral perfusion using the image intensifier camera, clinical studies were then undertaken

Arterial perfusion studies have been performed in 17 patients to date Some of these patients had cerebral or occlusive cerebrovascular disease (JOHNSON et coll 1968) while others displayed normal carotid or aortic arch angiograms All patients underwent arterial injection of ^{133}Xe or ^{99m}Tc pertechnetate immediately upon completion of angiography This required that the arterial needle or catheter remain in place for 5—10 additional minutes, but there was no evidence that the postangiography course of any patient was unfavorably affected thereby

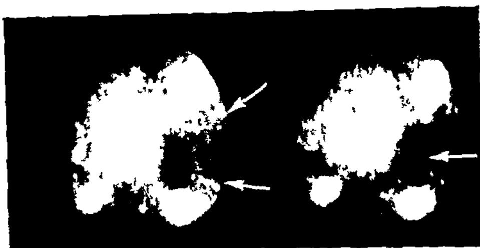


Fig 5 Lateral 5 second scintigrams of a 34 year old female suffering from acute occlusion of the left middle cerebral artery The image on the left was obtained 16—20 seconds after injection of ^{133}Xe into the left internal carotid artery the other image between 26—30 seconds after injection Perfusion is normal in the area supplied by the pericallosal artery but is nearly absent in the area supplied by the middle cerebral artery (arrows left view) Radioactive markers identify the outer canthus and external auditory meatus On both scintigrams the dark linear artifact (arrow right view) extending vertically from the latter marker was caused by focal oversaturation of the system

Scintigrams obtained during a normal study are presented in Fig 3 both the anterior and the lateral images are one second exposures begun 2 seconds after injection of the tracer into the carotid artery These show diffuse apparently uniform distribution of radioactivity throughout the ipsilateral hemisphere The anterior scintigram also indicates some contralateral perfusion, presumably via the anterior communicating artery

Since ^{133}Xe readily diffuses into the brain and has high solubility in cerebral matter its intracerebral residence is long relative to that of ^{99m}Tc pertechmetate The latter tracer merely passes through the vessels of the brain without entering the cerebral parenchyma therefore its intracranial residence is short The high concentration of ^{99m}Tc in the venous efflux usually outlines the dural sinuses and jugular bulb Fig 4) These structures may serve as end points for measuring the transit time of the cerebral circulation however their morphologic delineation lacks the resolution characteristic of radiographic display

An example of occlusive cerebrovascular disease involving the middle cerebral artery is shown in Figs 5 and 6 These scintigrams clearly show reduced perfusion in the region of that artery In the case shown in Fig 7 a localized perfusion deficit caused by resection of a frontal meningioma is evident however



Fig 6 Angiographic demonstration of occlusion of the left middle cerebral artery at its origin in the patient represented in fig 5

in this same case no perfusion abnormality was seen in the region of a second extra axial tumor in the posterior part of the falx near the tentorium This second lesion was supplied by branches of the posterior cerebral and pericallosal arteries

Studies of cephalic perfusion after intravenous administration of radioactive tracer have been handicapped by lack of follow up information An example of such a study, using ^{99m}Tc is shown in Fig 8 Each scintigram was exposed for 1 second A definite although asymmetric increment of cephalic radioactivity begins 10 seconds after injection and is maximal at 14—16 seconds Thereafter, rapid clearance of tracer occurs, with residual radioactivity remaining in the facial muscles and other structures We do not know if the asymmetrical entry of radioactivity into this patient s head has clinical significance

Discussion

Angiography is probably the oldest method of studying the macroscopic anatomy of the cerebral circulation However, it is less effective in displaying the capillary phase of the cerebral circulation The high speed scintillation cameras provide a potentially better method to display the cerebral microcirculation Thus the information acquired by these cameras complements conventional angiography With administration of radioactive xenon the parenchyma of the brain is displayed by these cameras whereas with radioactive pertechnetate ion the capillary phase of the cerebral circulation is outlined

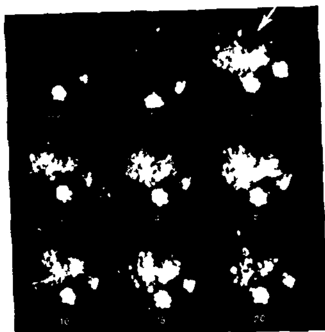


Fig 7 Serial lateral 1 second scintigrams of a 36 year-old male after injection of ^{133}Xe into the right internal carotid artery *There is a large focal* perfusion deficit (arrow) at the site of previous resection of a frontal meningioma Elsewhere perfusion is fairly uniform although a large vascular meningioma was demonstrated angiographically in the medial posterior parietal region

The image intensifier camera used in this work is to the best of our knowledge unsurpassed in terms of temporal or spatial resolution in comparison to other *currently available radioisotope imaging systems* It generates pictorial data showing the distribution and relative concentration of tracer in the parenchyma or microcirculation of the brain From these findings one may infer the state *of regional cerebral perfusion However data presentation by the image inten*sifier camera is non digital neither the scintigram nor the stored television signal is readily quantifiable at present Therefore total and regional cerebral blood flow cannot be quantitatively measured with the image intensifier camera. Nevertheless the analogue information has frequently been clinically valuable

Apparent non uniformity in cerebral distribution of tracer must be diffentiated from intrinsic variability in the sensivity of the system The field response of our image intensifier camera is not entirely homogeneous, thus reducing the useful crystal area available for scintillation imaging In addition, the camera shows the artifacts usually present with any television system i e ghost structures and oversaturation resulting in flare of the image We believe these artifacts can be eliminated with current technology

In other fields we have obtained excellent static images of radioactivity distributions in the thyroid liver and other organs It has also proved valuable in

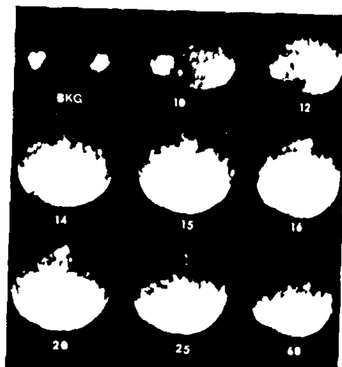


Fig 8 Anterior 1 second scintigrams of the head of a 72 year old female after peripheral intravenous injection of ^{99m}Tc pertechnetate Radioactive markers indicate location of outer canthi Tracer enters the head predominantly on the patient s left side as shown on the 10 and 12 second scintigrams The superior sagittal sinus is outlined at 15—20 seconds BKG—background

studies of arterial perfusion of the kidney and myocardium, to be reported elsewhere

Our present studies of cerebral circulation and regional cerebral flow are continuing, and later will provide a more complete evaluation of the usefulness of high speed scintillation imaging in this field

We believe that the displays of cephalic perfusion following peripheral intravenous administration of a tracer, as shown in Fig 8, have great potential value for screening patients suspected of having occlusive intra or extracranial cerebrovascular disease Further experience will determine whether this simple procedure has clinical merit

Acknowledgements

This investigation was supported in part by a grant from The John A Hartford Foundation The image intensifier camera (Picker Magnacamera) was kindly provided by Mr Frank H Low Picker Nuclear Division Picker X Ray Corporation White Plains New York U S A Xenisol containing xenon 133 in sterile saline was provided by Neisler Laboratories Tuxedo, New York U S A The technical assistance of Miss Pearl Varian and Miss Rita Martin is gratefully acknowledged

SUMMARY

The Ter Pogossian image intensifier scintillation camera was used to investigate the cerebral circulation and regional cerebral perfusion *in man with radioactive tracers* administered arterially The high speed display capability of the camera system permits sequential imaging of the cerebral circulation and other rapid dynamic as well as static, events Although the output of the camera system is pictorial not digital these scintigrams often complement the findings of conventional angiography

ZUSAMMENFASSUNG

Die Ter Pogossian Scintillationskamera mit Bildverstarker wurde verwendet um die cerebrale Zirkulation und die regionale cerebrale Perfusion beim Menschen nach arterieller Zufuhr von radioaktiven Indikatoren zu untersuchen Die hohe *Darstellungsgeschwindigkeit* des Kamerasystems ermoglicht eine fortlaufende Darstellung der cerebralen Zirkulation und anderer rascher dynamischer wie statischer Ereignisse Obwohl der Ausgang des Kamera systems visuell und nicht digital ist erganzen die Scintigramme oft die Befunde der konventionellen Angiographie

RÉSUMÉ

Le auteurs ont utilise la camera a scintillation et intensificateur d image de Ter Pogossian pour etudier la circulation cerebrale et l irrigation cerebrale regionale chez l homme au moyen de traceurs radio actifs administres par voie arterielle La rapidite du systeme à camera permet d obtenir une representation sequentielle de la circulation cerebrale et d autres phenomenes dynamiques rapides ou statiques Bien que le systeme a camera donne des resultats sous forme d image et non sous forme numerique ces scintigrammes completent souvent les resultats de l angiographie ordinaire

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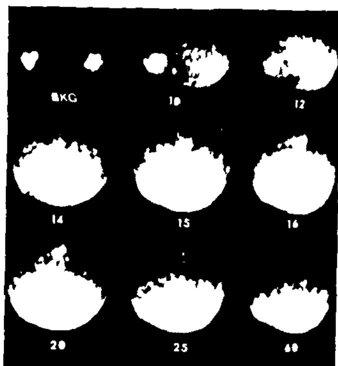


Fig 8 Anterior 1 second scintigrams of the head of a 72 year old female after peripheral intravenous injection of ^{99m}Tc pertechnetate Radioactive markers indicate location of outer canthi Tracer enters the head predominantly on the patient s left side as shown on the 10 and 12 second scintigrams The superior sagittal sinus is outlined at 15—20 seconds BKG—background

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ventriculostomy with porencephalic cyst serous meningitis and communicating hydrocephalus by the use of RISA subarachnoid scintigraphy Intraventricular isotope studies have shown ventricular obstruction intraventricular tumors, and patency and obstruction of ventricular shunts

Method The method used in this study is similar to that reported by others (Di Chiro et coll) A careful lumbar puncture technique is essential to minimize the leakage of activity from the subarachnoid space which might result in an inconclusive examination or a false positive examination An atraumatic midline lumbar puncture is performed with a small gauge (20 to 22) disposable spinal needle In doubtful cases the position of the needle within the subarachnoid space may be confirmed with appropriate roentgenograms after the injection of 0 2 ml Pantopaque or 5 ml of air In adults 5 ml of cerebrospinal fluid are withdrawn, mixed with 100 μCi of RISA and reinjected The dosage in the pediatric group is 25 to 50 μCi High specific activity RISA (available in 1% solution from Nuclear Consultants Division of Mallinckrodt Chemical Works) reduces the amount of albumin injected Following the removal of the spinal needle the patient is kept in a prone position prior to scanning Anteroposterior and lateral scintigrams of the head are routinely made at 2 and 24 hours with additional scintigrams as indicated A Picker 5 inch Magna scanner (with 5 inch Thallium activated sodium iodide crystal with 5 inch focusing collimator, with 75% ^{131}I isoresponse pattern measuring 9 mm$\times$55 mm) or a Nuclear Chicago Pho-Gamma III is used for scintigraphy The patient is given Lugol s solution to block the thyroid uptake of activity

Material Sixty two examinations were performed in 54 patients ranging in age from 3 months to 80 years Eight patients were in the 1st decade of life Thirty nine patients were in the 5th 6th or 7th decade The initial clinical diagnoses include dementia subarachnoid hemorrhage due to aneurysm incisural tumor infantile communicating hydrocephalus post meningitis status cerebrospinal fluid rhinorrhea and pseudotumor Thirty five of the fifty four patients had a clinical diagnosis of dementia. The diagno es in the 54 cases were as follows

Dementia	35
Infantile hydrocephalus	5
Meningitis	4
Cerebrospinal fluid rhinorrhea	4
Subarachnoid hemorrhage	2
Incisural tumor	2
Pseudotomor	1
Diabetic neuropathy	1

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ABNORMAL CEREBROSPINAL FLUID DYNAMICS AS STUDIED BY ISOTOPE SUBARACHNOID SCINTIGRAPHY

by

B B KILGORE, D O DAVIS and E J POTCHEN

It is the purpose of this paper to illustrate and discuss the patterns of distribution of radio iodinated human serum albumin (RISA) after its injection into the lumbar subarachnoid space with particular emphasis on the patterns noted in patients with hydrocephalus

In a study of the subarachnoid distribution of drugs after lumbar injection, external scanning was performed to determine intracranial distribution of the activity from ^{198}Au (RIESELBACH et coll 1962) The scintigrams demonstrated activity in the basal cisterns in an hour and its spread toward the convexity of the brain in three days The normal distribution of RISA in the subarachnoid space after a lumbar injection is well established and is indicated by activity in the basal cisterns in an hour which reaches the sylvian areas in 3 to 4 hours and then is seen over the convexity and along the superior sagittal sinus in 12 to 24 hours (DI CHIRO et coll 1964, DI CHIRO 1965) After intraventricular injection, the gamma activity quickly passes into the cisterna magna and then follows the same route to the convexity as described above

Various patterns of activity have been described in cerebrospinal fluid rhinorrhea, partial arachnoid block over the convexity, arachnoidal cyst, spontaneous

Table

Results of analysis of distribution of activity in scintigrams

Diagnosis	Normal	Delay in transit	Complete obstruction	Abnormal distribution					Unsatisfactory
				Ventricular	Mixed ventricular and subarachnoid	Unilateral convexity	Ventriculosubarachnoid fistula	Cerebrospinal fluid leak	
Dementia	15	6	2	1	5	5	—	—	1
Infantile hydrocephalus	2	—	—	2	—	—	—	—	1
Meningitis	1	—	1	1	1	—	—	—	—
Cerebrospinal fluid leak	—	—	—	—	—	—	—	4	—
Subarachnoid hemorrhage	—	—	1	1	—	—	—	—	—
Intracranial tumor	—	1	—	—	—	—	1	—	—
Pseudotumor	1	—	—	—	—	—	—	—	—
Diabetic neuropathy	1	—	—	—	—	—	—	—	—

criteria nine patients (9 examinations) out of the fifty four patients (62 examinations) had a complication Five of the nine patients had temperature elevation without signs of meningismus Four of these five patients also underwent encephalographic examination which provoked similar or greater temperature elevation Of the fifty four patients in the series forty three had air studies eighteen of whom developed changes which would place them in the group with complications With one exception the febrile reaction to encephalography equalled or exceeded that which followed the RISA study in patients in whom the two examinations were sufficiently separate to allow evaluation

The four patients who developed meningismus were children. The symptoms and signs cleared in 2 to 4 days usually without antibiotics The spinal fluid cultures which were performed in only two cases were negative Case 5 had a maximum temperature elevation to 38 4 following intrathecal RISA and 30°



Fig 1 A p and lateral scintigrams of the head at 2 and 24 hours illustrating normal distribution of activity in the subarachnoid spaces

Results

Because of the variety of diseases studied, an attempt was made to categorize the scintigraphic examinations into various patterns These include normal distribution and transit time of activity, normal distribution with a delayed time of activity, complete obstruction, and patterns with a variety of abnormal types of distribution Some of the examinations were not considered diagnostic

In the normal pattern the previously described distribution of activity in the early and delayed scintigram was observed (Fig 1) In the delayed pattern category, activity did not reach the parasagittal area until 48 to 72 hours after its lumbar injection The complete obstruction category included patients in whom the activity *failed to reach the basilar cisterns despite satisfactory lumbar* subarachnoid placement of the RISA Patterns with abnormal distribution include patients in whom the activity is predominantly within the ventricular system those with mixed ventricular and subarachnoid distribution those with unilateral distribution of activity over the convexity, a patient with post operative ventriculo subarachnoid fistula, and patients with cerebrospinal fluid leak The results are summarized in a Table

Complications With the interest generated by two recent reports (DETMER & BLACKER 1965, NICOL 1967) of aseptic meningitis following intrathecal RISA we examined this series of patients for possible complications It is recognized that headache, backache, tachycardia, pyrexia and meningismus may follow simple lumbar puncture These symptoms and signs are more common after the introduction of foreign material (including contrast material) into the subarachnoid space In this series, patients with meningismus or a temperature elevation above 37 8° C orally after the scintigraphic examination were arbitrarily classified as having a complication Patients whose only symptom after the examination was mild *headache or backache were not included* Using these arbitrary

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Meningitis	1	—	1	1	1	—	—	—	—
Cerebrospinal fluid leak	—	—	—	—	—	—	—	4	—
Subarachnoid hemorrhage	—	—	1	1	—	—	—	—	—
Incisural tumor	—	1	—	—	—	—	1	—	—
Pseudotumor	1	—	—	—	—	—	—	—	—
Diabetic neuropathy	1	—	—	—	—	—	—	—	—

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Fig 2 Pre-operative and post-operative encephalograms demonstrating the development of subarachnoid obstruction and hydrocephalus following the removal of a craniopharyngioma



Fig 3 Lateral scintigram at 24 hours showing ventricular pattern

following encephalography In Case 29, RISA was injected at the time of encephalography, complicating the evaluation of the reaction to RISA It has been suggested that the quantity of protein injected is responsible for the meningeal reaction In these four patients the amount of albumin varied from 1 0 mg to 1 6 mg A smaller amount of injected protein is possible using albumin tagged with technetium (^{99m}Tc) pertechnetate At present, this material is not commercially available Its use to evaluate surgical and spontaneous cerebrospinal fluid shunts has been reported (Di Chiro & Grove 1966)

Discussion

We are primarily interested in the use of RISA scintigraphy as an aid in the selection of patients who would benefit from ventricular shunting to relieve obstruction of the flow of the cerebrospinal fluid in the subarachnoid space The pathogenesis of subarachnoid obstruction is well established in some cases (Rus



Fig 4 Delay in the appearance of activity in the parasagittal areas. There is no essential difference in the 24 hour scintigram obtained 5 days before encephalography (a) and the one performed at the time of encephalography (b)



Fig 7 Partial obstruction of the subarachnoid pathways over the convexity on the left side

SELL 1949) Following subarachnoid hemorrhage patients may develop hydrocephalus from obstruction of the subarachnoid pathways secondary to the reaction excited by the blood on the meninges Other known causes of subarachnoid obstruction include basilar meningitis incisural tumors disorders of lipoid metabolism and fibrosis following surgery The etiology of the obstruction in certain patients is obscure These patients may present with dementia and may be difficult to distinguish clinically from degenerative processes such as Alzheimer s disease Cerebrospinal fluid pressure alone cannot be used as a differential point since symptomatic low pressure occult hydrocephalic patients have been successfully treated by ventricular shunt

The encephalogram is useful for the diagnosis of subarachnoid obstruction However it is not desirable to use encephalography as a screening procedure RISA scintigraphy is promising in this regard Its simplicity and low morbidity in adults are appealing when there is a need to evaluate large numbers of patients with dementia

If technical complications can be excluded the failure of activity to reach the cisterna magna suggests a subarachnoid block which should respond to shunting Preoperative and postoperative encephalograms in a patient with craniopharyngioma are presented in Fig 2 Postoperatively the patient reacted promptly but was noted to be disoriented and confused The decompression remained moderately tense although repeated lumbar puncture showed normal opening pressure Postoperative encephalography demonstrated ventricular dilatation and a subarachnoid block This patient had virtually no evidence of RISA activity intracranially in 2 or 24 hours. Her mental state improved rapidly with a ventriculoatrial shunt

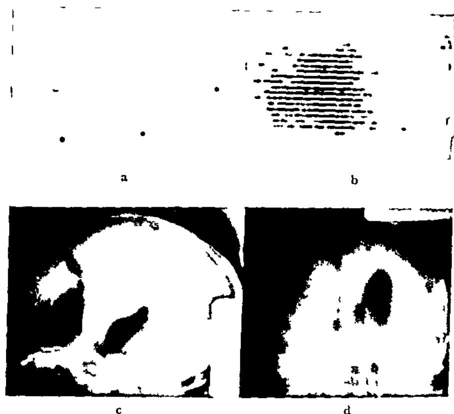


Fig 6 Post operative ventriculo subarachnoid fistula is seen at 2 hours (a) with a pool of activity at this site at 24 hours (b) The encephalogram confirmed the findings of the RISA scintigrams (c) and (d)

Subarachnoid obstruction appears to be excluded in the patients with normal distribution and transit time of the activity A predominantly ventricular pattern might be expected in patients with subarachnoid block since it has been shown that intraventricular absorption of cerebrospinal fluid is possible The symptoms and signs developing as a result of ventricular absorption insufficient to maintain cerebrospinal fluid equilibrium should be relieved by ventricular shunting In Fig 3, a scintigram from a patient with a ventricular pattern is recorded As yet, this patient has not been shunted

Other scintigraphic patterns are more difficult to correlate with clinical findings Normal activity distribution with delay in transit could be significant but the two patients with dementia with this pattern who have had ventriculo atrial shunts have not improved to date More experience is needed to evaluate this delayed pattern Such a scintigram is shown in Fig 4 Because of the problem of the effect of encephalography on cerebrospinal fluid circulation, it is interesting to note that there is little difference between the first RISA examination per

formed five days before encephalography and the second started at the time of encephalography Asymmetrical activity distribution over the convexity of the brain has been observed in a patient who had a subdural hematoma a year prior to the RISA examination This unilateral pattern in four other patients cannot be explained to date by the clinical or radiologic findings however (Fig 5) The findings in a patient with a ventriculo-subarachnoid fistula, following resection of the frontal tip for exposure during the removal of a craniopharyngioma, are illustrated in Fig 6 Postoperatively repeated taps of a pulsatile cerebrospinal fluid collection in the frontal area were required With scintigraphy, demonstration of the fistula follows within 2 hours after the lumbar injection of RISA, as seen on the lateral scintigram The 24 hour a p scintigram reveals dense activity at the site of the fistula with little or no activity over the convexity Encephalography confirmed the findings in the RISA examination Following ventricular shunting the taps were no longer necessary The patient s mental status transiently improved but she died as a result of destruction of the hypothalamus by the tumor

SUMMARY

RISA cintigraphy appears to represent a promising screening procedure for evaluation of patients with dementia who might have symptomatic low pressure hydrocephalus More clinical and physiologic data are necessary to fully appreciate the significance of many of the patterns of distribution and transit time seen with RISA scintigraphy

ZUSAMMENFASSUNG

RISA Szintigraphie scheint eine wertvolle Methode bei der Untersuchung von Patienten mit Demenz zu sein, um festzustellen falls Hydrocephalus bei niedrigem Druck ein symptomatisches Zeichen ist Es ist aber notwendig weitere klinische und physiologische Erfahrungen zu erwarten bevor es moglich ist die Signifikanz von vielen der verschiedenen Aktivitatserscheinungen und Durchlaufzeiten die man bei RISA Szintigraphie observiert, zu beurteilen

RÉSUMÉ

Il semble que la scintigraphie par la serum albumine marquee a l iode radio-actif (RISA) soit une methode interessante pour detecter les cas d hydrocephalie sans hypertension cranienne parmi les malades atteints de demence Une plus longue experience clinique et physiologique est nécessaire pour comprendre exactement la signification des differents types de distribution et des differents *temps de transit* que l on trouve par cette scintigraphie

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LABORATOIRE DE GAMMA ENCEPHALOGRAPHIE DE L INSTITUT DE RADIOLOGIE MEDICALE (PROF G CANDARDJIS) HOPITAL CANTONAL ET UNIVERSITAIRE LAUSANNE, SUISSE

CISTERNOGRAPHIE RADIO ISOTOPIQUE CHEZ LES HYDROCEPHALES POSTTRAUMATIQUES

Contribution a l etude de la dynamique pathologique du LCR

par

T Martini et R Oberson

Dans les suites des contusions et concussions cerebrales, l encephalographie *gazeuse iterative etablit le bilan* par exemple mensuel de la progression de l hydrocephalie Elle permet d apprecier dans une certaine mesure l efficacite d un artifice de drainage du LCR Mais l injection d un gaz dans les cavites cerebrales presente des inconvenients Elle n est pas toujours bien supportee Elle peut engendrer une poussee d oedeme cerébral ou precipiter l evolution d un syndrome psycho-organique vers la demence En outre elle ne fournit des renseignements sur la permeabilite des espaces sous-arachnoidiens pericerebraux que lorsque ceux ci sont insuffles Or dans ces cas d hydrocephalie importante les sillons corticaux sont difficiles a insuffler Le volume d oxygene etant limite par les risques encourus il n est pas possible d interpreter la non insufflation des sillons corticaux comme un signe d impermeabilite Enfin le gaz ne renseigne pas du tout sur la dynamique liquorale

La cisternographie radio-isotopique presente un double avantage Elle permet d observer la circulation du LCR marque La dynamique normale du LCR pericerebral est actuellement connue au moins dans ses grandes lignes A ce propos les cisternographies radio-isotopiques de Di Chiro (1964 1966) n ont fait que confirmer les etudes de Weed (1914) qui utilisait les index colores Les scinti

Tableau

Cisternographies péricérébrales chez les traumatisés cranio-cérébraux graves dont 19 hydrocéphales de degré modéré à important

	Cisterno-graphies	Malades
Cisternographies normales dont un malade non hydrocéphale	2	2
Fistulographies positives (rhinorrhées)	3	3
Anomalies essentiellement morphologiques	9	7
Anomalies essentiellement dynamiques		
Reflux cisterno-ventriculaire transitoire	1	1
Reflux cisterno-ventriculaire permanent	12	6
Fibrose basale et obstruction du Magendie	1	1
Total	28	20

grammes successifs ne montrent pas que le sens du mouvement liquidien. Ils fixent aussi l'image des citernes et des espaces sous-arachnoïdiens dont on peut ainsi déduire la perméabilité (GROS et coll. 1966). L'aspect dynamique est donc lié à l'analyse morphologique.

L'examen est bien toléré et n'engendre qu'exceptionnellement des céphalées, des nausées ou une hyperthermie dont la résolution est rapide. Il peut être difficile à réaliser chez un malade agité. La scintigraphie à l'aide d'appareils conventionnels exige 20 à 30 minutes par projection et l'immobilité stricte du sujet. La caméra à scintillation trouvera là probablement une bonne indication. L'étude la plus instructive est en effet celle de la progression du liquide marqué, ce qui nécessite de multiples contrôles.

Mais, la pathologie de la dynamique liquorale est encore mal connue. Les observations que nous publions, en particulier celles d'une inversion du mouvement liquoral dans les suites immédiates ou rapprochées d'un traumatisme cranio-cérébral grave, constituent une contribution à ce chapitre.

Matériel. Vingt-huit cisternographies radio-isotopiques ont été réalisées chez 20 malades dans les suites directes immédiates ou rapprochées d'un grave traumatisme cranio-cérébral (Tableau). Chez deux malades, la cisternographie était normale.

Tous nos malades souffraient d'une contusion cérébrale localisée ou multifocale. Dix d'entre eux étaient au stade du coma dépassé. La plupart avaient une fracture du crâne. Quelques-uns avaient subi une craniotomie ou une trépanation pour drainage d'un hématome juxtadural. Tous ont eu une ou plusieurs encéphalographies gazeuses pour suivre la progression de l'hydrocéphalie interne

posttraumatique L hydrocephalie etait toujours moderee ou importante Un seul blesse n a pas montre d hydrocephalie

Deux malades ont ete examines trois fois et cinq malades deux fois La serie comprend cinq enfants de 3 a 16 ans et quinze adultes du sexe masculin

Methode L appareil utilise est un biscanner (Mecaserto) Deux sondes opposees a balayage rectiligne vertical et horizontal permettent d enregistrer les deux profils ou les deux projections de face anterieure et posterieure en meme temps Les collimateurs sont focalises a 19 trous coniques les cristaux de 51 mm×51 mm

La serum albumine radio-iodee (SARI) a ete injectee 27 fois par voie cisternale a raison de 150 μCi pour les adultes et 50 a 75 μCi pour les enfants Deux fois nous avons injecte de l albumine marquee au pertechnetate (500 μCi) par voie cisternale Ce radiotraceur ne convient pas bien a ce genre d examen Sa periode physique est trop courte car les scintigraphies doivent etre pratiquees si possible 1 5 et 24 heures apres l injection Il est parfois difficile de respecter cet horaire chez un malade agite ou en mauvais etat general Chez un malade tres agite seulement nous avons marque le LCR par voie lombaire L injection lombaire donne les meme images cisternographiques que l injection cisternale mais plus tardivement C est pourquoi l injection cisternale nous semble preferable

Resultats

Cisternogramme normal

La distribution sous arachnoidienne pericerebrale normale d un radiotraceur introduit (par injection directe) ou parvenu (apres myeloscintigraphie) dans la grande citerne est maintenant etabli (Di Chiro) L ensemble des images observees par leur disposition et leur progression, constitue le cisternogramme normal Il est caracterise au double point de vue de la morphologie et de la physiologie L aspect varie d heure en heure realisant a chaque fois une image typique facile a interpreter aussi bien de face que de profil (Fig 1) La presence du LCR marque dans une citerne indique qu elle est permeable et que la voie arachnoidienne sous-jacente par consequent l est aussi L appreciation de la dynamique liquorale decoule de l analyse morphologique puisque le LCR suit normalement une voie preferentielle qui va de la grande citerne dans les vallees sylviennes via les citernes basales pour remonter en 24 heures jusqu aux para medianes des convexites fronto-parietales

La cisternographie est en fait l extension aux espaces sous-arachnoidiens peri

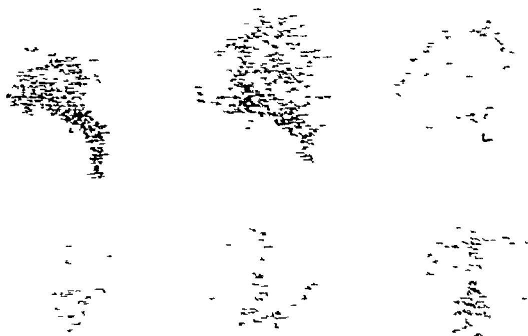


Fig 1 Cisternogramme normal a la ^{131}SARI Progression normale du radiotraceur chez un adulte En haut les vues de profil gauche en bas les vues anterieures. Deux heures p.i. (a gauche) le radiotraceur marque le LCR des citernes basales, un peu moins celui des vallees sylviennes et du reseau cisternal interhemispherique Six heures p.i. (au milieu) le radio traceur a progresse fortement dans les vallees sylviennes et contamine deja faiblement les espaces de la convexite et 24 heures p.i. (à droite) l albumine marquee en bonne partie resorbee est detectee principalement sur les convexites. Absence d image ventriculaire

cerebraux de l exploration de la permeabilite des espaces perimedullaires. Nous avons obtenu une cisternographie cerebrale normale a la suite de 30 myeloscintigraphies. Dans 25 cas, le radiotraceur avait ete injecte par voie cisternale. En outre, 10 malades de tous ages, injectes par voie sous-occipitale pour une cisternographie selective (8 recherches negatives de fistule 2 recherches negatives de collections meningees ou de malformation) ont aussi montre un cisternogramme normal Nous disposons donc au total de 40 cisternogrammes normaux Il n a jamais ete observe de reflux cisterno-ventriculaire dans ces cas.

Cisternogramme pathologique

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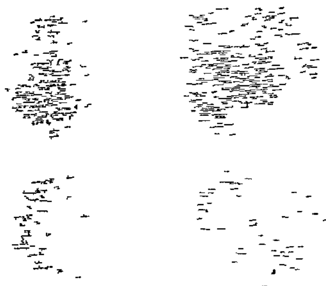


Fig 2 Cisternogramme pathologique anomalies essentiellement morphologiques asymetrie de la distribution du LCR marque dans les vallees sylviennes Malade de 3 ans avec contusion cerebrale A gauche vues anterieures à droite profils droits. En haut 6 heures après l injection cisternale dilatation (prestenotique) de la vallee sylvienne droite permeabilite normale du systeme cisternal median et de la convexite gauche Comme il est normal chez les enfants le transport liquidien de l albumine marquee est rapide d ou l image radio-active de la convexite En bas 24 heures p i image en croissant demontrant par le retard considerable du mouvement liquidien l alteration de la permeabilite de l arachnoide de la convexite droite (foyer de contusion) A gauche resorption totale du radiotraceur

traince vers la fistule (ZANDER & OBERSON DI CHIRO & REAMES 1964) Le reste suit les voies generales normales de la resorption

B *Anomalies essentiellement morphologiques* Ce groupe comprend 9 cisternographies realisees chez 7 malades Deux types d anomalies peuvent etre illustrees

Dans les cas d impermeabilite haut situee unilaterale localisee par exemple a une vallee sylvienne ou a une convexite les troubles dynamiques sont moderes et n affectent pas le sens du mouvement liquoral principal au point de l inverser Cette permeabilite segmentaire est en general due a une fibrose leptomeningee postcontusionnelle Le cisternogramme semble altere essentiellement du point de vue morphologique La repartition du radiotraceur est asymetrique, temoignant d une stenose segmentaire plus ou moins complete avec ou sans vicariance controlaterale des espaces sous-arachnoidiens Parfois une dilatation prestenotique peut etre mise en evidence (Fig 2)

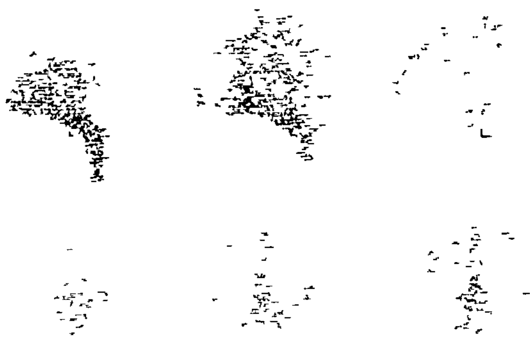


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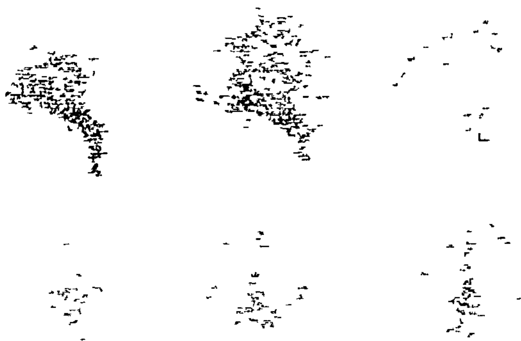


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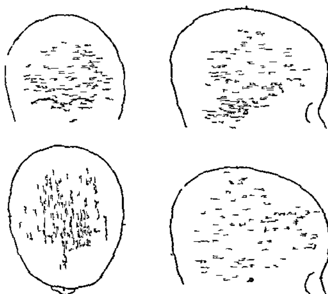


Fig 5 Cisternogramme pathologique Reflux cisterno-ventriculaire transitoire Malade de 7 ans renversee par une voiture coma prolonge contusions cerebrales multiples. Le reflux est observe 3 heures apres injection cisternale sur la vue anterieure en haut à gauche et laterale à droite et axiale en bas à gauche Vingt quatre heures p i le cisternogramme de profil en bas ne montre plus d image ventriculaire reconnaissable Sur les vues de face et axiale les vallees sylviennes sont legèrement radio-actives. Le retard de la progression du LCR marque est ici evident A 24 heures p i une partie seulement de l albumine marquee à éte transportee jusque sur la convexite Chez un enfant il n y a normalement plus de radiotraceur détectable au controle des 24 heures On doit admettre une permeabilite imparfaite des sillons sylviens et de la convexite

propose Di Chiro la question d une eventuelle contamination ventriculaire physiologique a partir de la citerne cerebello-medullaire soit tranchee S il existe ce marquage du liquide ventriculaire est minime

Un reflux cisterno ventriculaire pathologique a ete observe dans 7 cas L image ventriculographique est facile a reconnaitre de face et de profil Le contraste est net des le premier examen 1 ou 2 heures apres l injection Il est maximal 5 ou 6 heures p i Au controle des 24 heures p i il est parfois plus faible temoignant alors de la resorption locale

Chez trois malades la cisternographie a ete repetee une ou deux fois, avec la meme image de reflux Au total 12 cisternographies montraient l inversion du courant

Lorsqu a une phase de reflux ventriculaire massif observee dans les premieres heures succede une phase d evacuation ventriculaire lente 24 heures apres l in jection il faut admettre un ralentissement circulatoire global du LCR donc une



Fig 3 Cisternogramme pathologique reflux cisternoventriculaire 2 heures (en haut) et 24 heures (en bas) après injection cisternale Le malade avait 27 ans fracture de la base du crane contusion cerebrale A gauche vues anterieures à droite profils droits La forme des ventricules lateraux dilates est aisement reconnue Les cisternes basales sont permeables impermeabilite de l arachnoide des vallees sylviennes et des sillons des convexites (verification anatomique)

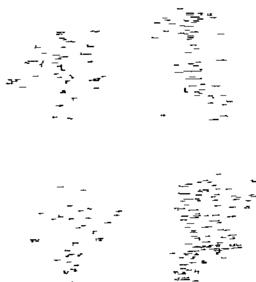


Fig 4 Cisternogramme pathologique reflux cisterno ventriculaire permanent ici 2 heures après injection cisternale En haut vue anterieure (à gauche) et profil gauche (à droite) En bas vue posterieure et profil droit Le malade avait 48 ans fracture fronto-parietale gauche hematome sous dural aigu et contusion temporo basale droite dilatation des ventricules lateraux predominant sur la corne temporale droite Le reflux suppose l impermeabilite des voies arachnoidiennes de resorption de l albumine marquee les lesions traumatiques interessaient les deux convexites

C *Anomalies essentiellement dynamiques* Le trouble de la dynamique liquorale est au premier plan lorsqu on assiste a une inversion complete du mouvement, c est a dire a un reflux cisterno ventriculaire du LCR Au lieu d une cisternographie, on realise alors involontairement une ventriculographie radio isotopique par voie cisternale (Figs 3, 4 et 5)

Di Chiro (1966) a signale que ce phenomene de contre courant s observait occasionnellement Il en donne un exemple Dietz et coll (1966) en presentent un autre cas Il est interessant de constater que la ventriculographie par voie cisternale de Di Chiro et celle de Dietz ont toutes deux ete realisees chez des hydrocephales Chez le chat, Fleischhauer (1966) indique que « les substances injectees dans la grande citerne sont demeurees presque exclusivement a la surface externe du cerveau et de la moelle et n ont penetre qu en quantites infimes dans le systeme ventriculaire »

Il est possible qu en pratiquant des tomogrammes radioisotopiques, comme le

gazeuse on n avait obtenu ni cisternographie ni ventriculographie (obstruction anatomique des citernes basales et du trou de Magendie) La ventriculographie gazeuse mettait en evidence une hydrocephalie interne tres importante A l au topsie fut confirmee l importante fibrose leptomeningee chiasmatique, interpedonculaire et prepontique Cette absence totale de LCR marque dans l endocrane constitue l image de l alteration morphologique (et dynamique) la plus complete des espaces sous-arachnoidiens pericerebraux

Discussion

La distinction entre anomalies morphologiques et dynamiques est artificielle puisque les deux *elements sont fortement intriques Cette classification* n a d in teret que pour la semeiologie

Le facteur cle est la permeabilite des citernes basales medianes Si la lesion anatomique des leptomeninges est unilaterale et plus haut situee ou s il existe une fistule de LCR le cisternogramme montrera essentiellement la topographie de la lesion Si les citernes basales sont impermeables, le courant liquidien principal transportant les albumines marquees est interrompu et on obtient au lieu d une cisternographie une ventriculographie par voie cisternale Cette ventriculographie est transitoire lorsque les citernes basales n ont qu une permeabilite diminuee Elle persiste 24 et 48 heures apres l injection lorsque l impermeabilite basale est totale On est tente d interpreter ce phenomene comme celui d un reflux cisterno ventriculaire du LCR marque En fait des facteurs autres que hydrodynamiques pourraient intervenir par exemple l existence d une pression differentielle entre le systeme ventriculaire et les espaces sous-arachnoidiens L etude des hydrocephales non traumatiques apportera peut-etre une explica tion a ce phenomene du marquage preferentiel du LCR ventriculaire et une cor rection de notre interpretation hypothetique actuelle Pour l heure c est la notion d une *inversion du sens du courant liquidien qui rend le mieux compte de* la ventriculographie observee Il reste a savoir si le LCR non resorbable par la voie habituelle pouvait etre resorbe la ou il est produit

L *interet therapeutique des etudes qui sont poursuivies est de* renseigner le clinicien sur les conditions de circulation du LCR Si comme l indique la verification anatomique de quatre malades ayant montre un reflux l inversion massive *et irreversible du courant liquidien est* temoin de l impermeabilite des citer nes basales des deux voies sylviennes ou des deux convexites l indication a un drainage chirurgical du LCR chez les hydrocephales pourrait etre donnee par la *cisternographie* radio-isotopique (ZANDER et coll) Les hydrocephalies occultes symptomatiques de l adulte (ADAMS et coll HOGAU & WOOLSEY 1966) pour raient etre evaluees par le meme procede avant d etre traitees de la meme façon

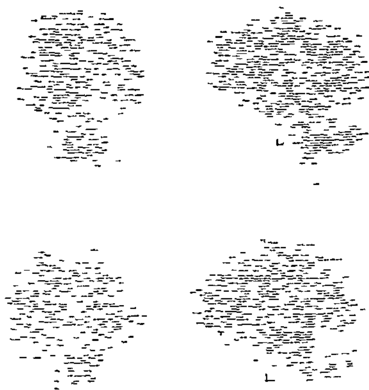


Fig. 6. Cisternogramme pathologique, même cas que sur la figure 5. Reflux cisterno-ventriculaire global quatre mois après drainage ventriculaire selon Spitz-Holter. La valve ne fonctionne plus depuis un mois. Hydrocéphalie interne volumineuse reconnaissable sur les vues antérieure, postérieure et latéral 6 heures après injection cisternale. Le profil gauche 24 heures p.i. qui se trouve en bas à droite montre que le reflux est permanent et la résorption du radiotraceur très faible. Fibrose arachnoïdienne péricérébrale (vérification anatomique).

imperméabilité relative des voies de drainage (Fig. 5). Nous parlons alors de reflux transitoire.

Il est plus rare d'observer l'imperméabilité totale des citernes basales et du carrefour bulbo-cervico-amygdalien, comme chez l'homme de 26 ans qui resta dans un état démentiel grave dix mois après un grave traumatisme cranio-cérébral. Un hématome sous-dural bilatéral avait été évacué. Après quelques mois de coma, la démence profonde s'était installée. En raison de l'agitation de ce malade, le radiotraceur fut injecté exceptionnellement par voie lombaire. La SARI qui n'a pas progressé au delà de la portion cervicale de la grande citerne, en dépit de contrôles tardifs, n'a pas été détectée non plus dans les ventricules. Une craniotomie occipitale bilatérale deux mois après le traumatisme avait montré de nombreuses adhérences lepto- et pachyméningées de la fosse postérieure, en particulier autour des orifices du IVe ventricule. A l'encéphalographie

FROM THE DEPARTMENTS OF RADIOLOGY HOMESTEAD HOSPITAL, UNIVERSITY SCHOOL OF MEDICINE PITTSBURGH, PENNSYLVANIA, U S A

ACCURACY OF BRAIN SCANNING

Comparison with other procedures for brain tumor detection

by

YEN WANG

The methods used for brain tumor detection before 1948 consisted of angiography pneumography and electroencephalography In that year, MOORE reported on the use of ^{131}I diiodofluorescein as an agent for brain tumor localization with tracer techniques Brain scanning with either ^{131}I serum albumin (RISA) ^{03}Hg chlormerodrin (neohydrin®) ^{197}Hg neohydrin® or ^{99m}Tc is now widely employed as a screening test for intracranial lesions (CHOU et coll 1951, BLAU & BENDER 1959 SODEE 1963)

The accuracy of brain scanning has been reported to be from 50 to almost 100 % by various authors This wide variation is due in part to different criteria used for calling a scan positive differences in technique and differences in the relative percentages of different tumors represented in a series Most laboratories can detect meningiomas and glioblastomas with greater than 90 % accuracy whereas midline tumors posterior fossa tumors and relatively benign astrocytomas are detected much less frequently

The purpose of this retrospective study has been to assess the accuracy of the

This work was in part supported by grant RH00350 01 National Center for Radiological Health PHS U S A

RÉSUMÉ

Les hydrocephalies postcontusionnelles sont parfois du type communicant avec résorption bloquée Dans ces cas la cisternographie radio isotopique montre une inversion du sens du courant liquidien normal On peut appeler provisoirement ce phenomene, le « reflux cisterno ventriculaire » Sa constatation semble porter une indication precise à la mise en place d un systeme de drainage du liquide ventriculaire

SUMMARY

The post traumatic hydrocephalus is sometimes of the communicating type with blocked resorption Cisternography with a radioisotope will then show reversal of the normal flow of the cerebrospinal fluid which provisionally may be called cisternoventricular reflux This finding should be a definitive indication to perform drainage of the ventricular liquid

ZUSAMMENFASSUNG

Post traumatischer Hydrocephalus kann bisweilen in der kommunizierenden Form mit blockierter Resorption vorkommen Cisternographie mit einem Radioisotop wird dann einen Ruckfluss der cerebrospinalen Flussigkeit aufweisen was vorlaufig cisternoventrikularer Ruckfluss genannt werden kann Dieser Befund sollte eine definitive Indikation fur Drainage der ventrikularen Flussigkeit ausmachen

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Table 2

Accuracy of diagnostic procedures used in detecting 44 histologically proved tumors

	Brain scan	EEG	SEG	Skull films	Angiography	Pneumography
Number of patients	44	38	22	36	36	16
Positive results	34	20	9	7	25	10
Questionable results	4	8	1	5	5	6
Negative results	6	10	12	24	6	
Percentage of positive results	77	53	41	19	69	63
Percentage of positive and questionable results	86	74	45	33	83	100

Table 3

Accuracy of combinations of procedures in detecting 44 histologically proved tumors

	Scan and EEG	Scan EEG and SEG	Scan EEG and skull film	Scan EEG SEG and skull film	Angiography and pneumography
Number of patients	44	44	44	44	39
Positive results	35	36	36	37	31
Questionable results	5	4	6	5	6
Negative results	4	4	2	2	2
Percentage of positive results	80	82	82	84	79
Percentage of positive and questionable results	91	91	95	95	95

Table 4

Accuracy of brain scanning, angiography and air contrast studies as reported in the literature

	Brain scan		Angiography		Pneumography	
	Number	Percent	Number	Percent	Number	Percent
McAfee and Taxdal	71	73	43	70	21	76
Dugger & Pepper	27	93	27	93	6	83
Aronow (includes positive results for glioblastomas and meningiomas only)	298	86	173	79	85	84
Aronow (includes positive and probably abnormal results for glioblastomas and meningiomas only)	298	96	173	94	85	84

Table 1

Accuracy of the brain scan in detecting 44 histologically proved tumors

Tumors	Positive	Questionable	Negative	Total
Glioblastoma	12	1		13
Meningioma	10		1	11
Metastases	7		3	10
Astrocytoma	3	1	1	5
Glioma	1			1
Chromophobe adenoma	1			1
Oligodendroglioma		1		1
Acoustic neurinoma		1		1
Sarcoma			1	1
Total	34	4	6	44

brain scan in comparison with other procedures in use for brain tumor localization and to review briefly the results of other comparative studies that have been published The usefulness of brain scanning as a routine screening procedure in detecting many intracranial diseases will be established and emphasized

Material and Methods Hospital records were obtained for all of the 518 cases who had a ^{203}Hg neohydrin brain scan in the period June 1962 to April 1965 at the Presbyterian University Hospital in Pittsburgh Forty four of these cases had histologic evidence of neoplastic disease involving the brain or meninges, either as a primary or metastatic process The histologic diagnosis was in most cases established by surgery and otherwise by autopsy The tumor composition and brain scan accuracy for each tumor type are given in Table 1

The results of brain scanning, electroencephalography (EEG), sonoencephalography (SEG), conventional skull films, angiography and pneumography in detecting the 44 histologically proven tumors are listed in Table 2

The accuracy of various combinations of minor procedures (brain scan, electroencephalography, sonoencephalography and skull films) in screening for brain tumors is recorded in Table 3, while the accuracy of brain scanning, angiography and air contrast studies, as reported by three other authors (McAfee et coll 1961, Aronow 1962, Dugger et coll 1963) is presented in Table 4

Discussion

Data showing the accuracy of the various diagnostic procedures for brain tumor localization have been presented The brain scan was negative in six out of our forty four cases of verified tumor One of these was a sphenoid wing

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	Number	Percent	Number	Percent	Number	Percent
McAfee and Taxdal	71	73	43	70	21	76
Dugger & Pepper	27	93	27	93	6	83
Aronow (includes positive results for glioblastomas and meningiomas only)	298	86	173	79	85	84
Aronow (includes positive and probably abnormal results for glioblastomas and meningiomas only)	298	96	173	94	85	84

meningioma where the diagnosis was confirmed by both angiography and pneumography. One was a sarcoma where pneumography established the diagnosis but the other studies, including angiography, were negative. Of the three metastatic tumors one was questionable on electroencephalography and one was demonstrated on electroencephalography but missed by both angiography and pneumography.

Of the minor studies, the brain scan had the highest accuracy. Furthermore, this accuracy parallels that of angiography and pneumography. The combination of brain scanning, electroencephalography, and conventional skull films failed to demonstrate a tumor, either positively or questionably, in only two cases. One of these was a metastatic lesion demonstrated by pneumography but missed by angiography, and the other was a sarcoma also demonstrated by pneumography but missed by angiography.

The relative advantages and disadvantages of each procedure have been presented in the literature by many authors. The advantages of brain scanning over the major procedures are (1) lack of patient morbidity, (2) demonstration of the lesion, and (3) ease and safety of repeated studies to follow the course of a lesion treated by surgery or radiotherapy, or both. The disadvantages of brain scanning are that (1) it may be positive in conditions other than tumors, such as hematoma, abscess, granuloma, arteriovenous malformation, aneurysm, encephalomacia and cerebrovascular accidents, (2) it does not demonstrate normal anatomical relationships as well as the major studies do, and (3) it gives a relatively high irradiation dose to the patient.

SUMMARY

In only 5% of 44 cases of verified brain tumor did a combination of brain scanning, electroencephalography, and conventional skull films fail to show abnormality. This degree of accuracy is the same as obtained with angiography and pneumography combined. The minor procedures do not obviate the necessity of performing a major procedure since the latter will offer additional information. Accumulated data support the view, however, that reliance may be put on brain scanning and the other non-traumatic diagnostic procedures in their accuracy to exclude a mass lesion of the central nervous system, except when the clinical syndrome obviously calls for angiography or pneumography.

ZUSAMMENFASSUNG

In nur 5% von 44 verifizierten Gehirntumoren war es unmöglich eine Anomalie nachzuweisen, wenn eine Kombination von Gehirnszintigraphie, Elektroenzephalographie und konventioneller Röntgenuntersuchung des Schädels zur Anwendung kam. Dies weisst auf dieselbe Genauigkeit wie bei einer Kombination von Angiographie und Pneumographie. Die verhältnismässig einfacheren Verfahren durften keineswegs dazu leiten, dass man auf die

mehr umfassenden Untersuchungen bei denen zusätzliche Information erreicht werden kann verzichtet Die Ergebnisse unterstutzen die Auffassung dass man mit den erwähnten nicht traumatisierenden Methoden die Anwesenheit einer Tumormasse im Zentralnervensystem darstellen kann mit Ausnahme von den Fallen in denen das klinische Syndrom deutlich Angiographie oder Pneumographie indikiert

RÉSUMÉ

L association de scintigraphie cerebrale d electroencéphalographie et de radiographies simples du crane n est restee negative que dans 5 % de 44 cas prouves de tumeur cérébrale Ce degre de precision est le meme que celui de l association de l angiographie et de la pneumographie *Ces techniques mineures ne s opposent pas a la necessite de pratiquer une* technique majeure car celle ci fournira des renseignements supplementaires Cette etude vient confirmer l opinion qu on peut se fier a la scintigraphie cerebrale et aux autres methodes atraumatiques de diagnostic pour exclure la presence d une tumeur du systeme nerveux central sauf quand le syndrome clinique rend necessaire de façon evidente une angiographie ou une pneumographie

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ULTRASOUND AND THERMOGRAPHY

FACIAL THERMOGRAPHY

by

N J M Aarts

Thermography is a method of defining a process of disease from temperature differences, although the actual temperature may also, if necessary be calculated The diagnosis is however based on the temperature differences which normally do not exceed 0 2 to 0 5° C between symmetrical regions

In the present studies, the Swedish Thermovision (AGA) has mainly been used A normal thermogram (Fig 1) consists of a symmetric pattern of white and black dots with predominating grey tones White signifies a relatively warm spot whereas black represents a relatively cold spot, with white grey or black grey as intermediates Normal cold regions of the face are the nose, cheeks, chin, ears, cornea, eyebrows, eyelashes and hair Normally warm are the forehead, the surroundings of the eyes and the mouth and the nasolabial region The border line between the superficial temporal artery region and the adjacent part of the forehead is sharp

It is important that the head should lie as symmetrically as possible to the thermograph, errors may otherwise arise

Cases with total or partial stenosis of the common or internal carotid artery proximal to the origin of the ophthalmic artery, and therefore localized mainly extracranial, exhibit a cold zone homolateral to the mid supra orbital region, where the supra orbital branch of the ophthalmic artery reaches the surface A

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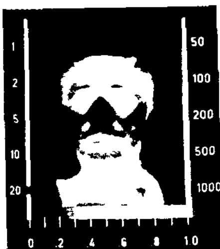


Fig 1 Normal thermogram Symmetric pattern of white and black dots with numerous grey tones white indicates warm and black cold parts

blocked common carotid artery produces a depression of the temperature level also in the region of the homolateral superficial temporal artery The anatomical relations are presented in Fig 2 The extracranial localizations of obstruction of the carotid artery are numerous the common ones have been given by FISHER (Fig 3)

A cold zone in the thermogram indicates an abnormality of the carotid circulation on that side (Fig 4)

As only temperature differences are recorded comparison of the left and right sides is essential bilateral obstruction is thus difficult to diagnose A diminished circulation of 50 to 60 per cent is necessary to obtain a pathologic thermogram whereas clinical signs of intermittent ischemic cerebrovascular accidents probably do not occur unless there is at least a 70 per cent degree of stenosis

Table

Comparison of results obtained with thermography and arteriography

	Thermography	Arteriography	
		Normal	Pathologic
Normal	30	30	—
Probably normal	1	1	—
Pathologic	26	8	18
Probably pathologic	4	—	4

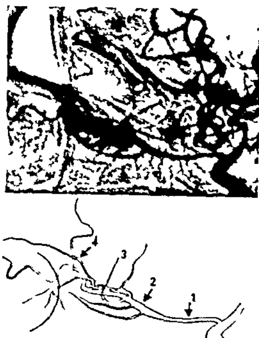


Fig 2 Subtraction view and schematic drawing of the ophthalmic artery and its terminal branch the supra-orbital artery Parts of the ophthalmic artery infra optic (1) latero optic (2) supra optic (3) and the supra orbital artery (4) (After DILENGE FISCHGOLD & DAVID 1965)

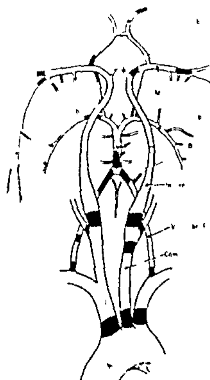


Fig 3 The most common localizations of obstruction of the carotid artery (after FISHER) the obstructions mostly lie out side the cranium

The surgical treatment of vascular disease is possible only in the extracranial part of the carotid circulation so that thermography may be used as a screening method prior to angiography Thermography is completely harmless is easy, quick and practical and may be performed almost without any cooperation of the patient, even a fully unconscious patient may be examined An early tracing of a cerebrovascular disturbance, even before clinical signs appear, may be obtained

The purely intracranial vascular lesion producing thermographic changes will give rise to a steal phenomenon in the ophthalmic artery region This may occur in arterio-venous shunts and in large although not in small aneurysms Restoration of a circulation following operation will be indicated by a normal thermogram

The first series of facial thermography totalled 61 patients all controlled by angiography, and 32 of whom had a normal and 29 a pathologic thermogram A normal angiogram was obtained in 30 out of the 32 patients (94 %) Some irregularity of the right internal carotid artery with thermographic changes was evident in one patient, clinical signs were absent

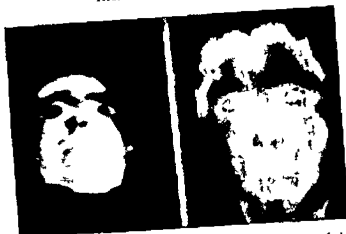


Fig 4 a) Left supra-orbital cold zone indicating stenosis of the internal carotid artery b) Diminished circulation indicated by the left supra-orbital cold zone caused by an arteriovenous shunt in the middle cerebral artery

The second patient with a normal thermogram had narrowing of the left internal carotid artery with vague changes on the right side This was due to an error in interpretation as rereading disclosed a small cold zone on the right side The difficulties that arise in bilateral impaired circulation were thus emphasized

Of the 29 pathologic thermograms confirmation by angiography was obtained in 22 patients (74 %) The remaining seven patients had no angiographic abnormality It has not been possible to explain this discrepancy Although the series was small there was nevertheless evidence of a fairly good correlation between normal thermograms and angiography Thermography may therefore be recommended for use as a screening method in patients displaying possible cerebrovascular disturbances

SUMMARY

Facial thermography based on a material of 61 cases in which angiography was also performed is described The method is quick simple and without danger It would appear to merit a place in the screening of patients with cerebrovascular disease

ZUSAMMENFASSUNG

An einem Material von 61 Fallen in denen arteriographische Resultate bekannt waren wurde die faciale Thermographie ebenfalls vorgenommen Die Methode ist rasch einfach und gefahrlos Es scheint berechtigt zu sein dass die Methode fur die Untersuchung von Patienten mit cerebralen Gefasserkrankungen ofter zur Anwendung kommt

RÉSUMÉ

L'auteur, se basant sur une serie de 61 cas dans lesquels une angiographie a aussi été effectuée, décrit la thermographie de la face. Cette methode est rapide, simple et sans danger. Elle parait mériter une place dans les examens de triage des malades atteints d'affection cérébro-vasculaire.

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AUS DER NEUROCHIRURGISCHEN UNIVERSITATS-KLINIK (DIREKTOR PROF W SCHIEFER), ERLANGEN NURNBERG DEUTSCHLAND

ECHOENCEPHALOGRAPHIE UND KONTRASTMITTEL METHODEN IN DER DIAGNOSTIK RAUMFORDERNDER PROZESSE DER HINTEREN SCHADELGRUBE

von

V Brockhoff E Kazner und W Schiefer

Die diagnostischen Moglichkeiten der Echoencephalographie erschopfen sich nicht in der Erkennung supratentorieller Raumforderungen durch Nachweis einer Verlagerung des Mittelechos sie lassen sich auch fur Prozesse der hinteren Schadelgrube auswerten An einem Krankengut von 200 Patienten mit Raumbeschrankungen im Bereich der hinteren Schadelgrube wurde in den letzten 5½ Jahren die prae und postoperative Diagnostik durch eine Kombination von Echoencephalographie mit Kontrastmittelmethoden und zwar der percutanen Vertebralisangiographie sowie der Ventriculographie mit Luft oder mit Pantopaque vorgenommen

Haben Vorgeschichte und klinischer Befund den Verdacht auf einen Prozess in der hinteren Schadelgrube aufkommen lassen so klaren wir zuerst mit der Echoencephalographie ab ob eine Erweiterung des 3 Ventrikels und der Temporalhorner vorliegt (Schiffer & Kazner 1964) Um aus der Lage der Reflexionen des Temporalhorns Ruckschlusse auf das Ausmass einer Ventrikelerweiterung zu ziehen haben wir einen echoencephalographischen Hirnmantel index angegeben (Kazner & Schiefer 1966) Eine Erweiterung der Hirnkam

RÉSUMÉ

L'auteur se basant sur une série de 61 cas dans lesquels une angiographie a aussi été effectuée décrit la thermographie de la face Cette méthode est rapide simple et sans danger Elle paraît mériter une place dans les examens de triage des malades atteints d'affection cérébro-vasculaire

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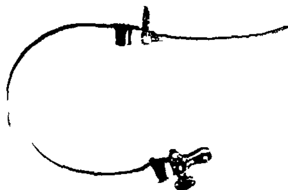
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Spezial Punktionskanule fur die percutane Vertebralis-angiographie

passagerer Natur sind treten am haufigsten auf Wir selbst beobachten 4 mal eine derartige Komplikation

Die Deutung der Angiogramme wird erleichtert wenn die pathologischen Ge *fassverlaufe in Verlagerungssyndromen zusammengefasst werden* wie dies erst mals TIWISINA (1956 1964) konsequent durchfuhrte

Auf Aquaeduktstenosen weist neben der Langsschnittanamnese und dem kli nischen Befund vornehmlich die durch das Echoencephalogramm fassbare exces sive Erweiterung der Hirnkammern hin Der Mittelwert fur die Erweiterung des 3 Ventrikels liegt hier bei 17 3 mm Wenn kein weiterer Hinweis fur die An nahme eines Neoplasmas vorliegt nehmen wir eine Ventriculographie mit Panto paque vor wobei die Stelle des Verschlusses einwandfrei zur Darstellung kommt

Kleinhirnabszesse der Mittellinie konnen zuweilen das Bild eines Aquaedukt verschlusses bieten und sich dem angiographischen Nachweis entziehen Auch hier ist dann die Pantopaque Ventriculographie die Methode der Wahl Das Echogramm zeigt dabei allerdings eine geringere Erweiterung Sollte sich bei der Pantopaque Ventriculographie eine Verlagerung des Aquaeduktes und somit der Hinweis fur ein Neoplasma ergeben so wird eine Vertebralisangiographie an geschlossen

Auch alle Kleinhirngeschwulste zeigen im Echoencephalogramm eine deut liche Erweiterung des 3 Ventrikels mit einem Mittelwert von 14 4 mm Die Vertebralisangiographie ergibt in vielen Fallen eine Darstellung des Tumors durch Gefassanfarbung oder Randgefassbildung

Fur die Akustikusneurinome fanden wir im Echoencephalogramm bei 41 von 51 Patienten eine Erweiterung des 3 Ventrikels auf durchschnittlich 10 0 mm

Bei *Tumoren des Hirnstammes* wird ausser der Echoencephalographie so-

Tabelle

Echo-encephalographische Befunde bei 200 raumfordernden Prozessen in der hinteren Schädelgrube

Diagnose	Anzahl	3. Ventrikel normal weit	3. Ventrikel erweitert	Mittlere Weite des 3. Ventrikels
Kleinhirntumor	77	—	77	14,4 (mm)
Aquaeduktverschluss	23	—	23	17,3
Akustikusneurinom	47	6	41	10,0
Tumor des caudalen Hirnstammes	8	1	7	11,1
Sonstiges	41	5	35	11,0
Total	200	12	183	
	100 %	6,0 %	91,5 %	

mern ist im Echogramm bei allen Aquaeduktverschlüssen und Kleinhirntumoren, jedoch nur bei 4/5 der Kleinhirnbrückenwinkeltumoren nachweisbar und ihr Ausmass lässt bereits eine Vorklassifizierung zu, wodurch die Wahl der nachfolgenden Kontrastmittelmethode determiniert wird. Die Tabelle zeigt in der letzten Spalte die Mittelwerte der Erweiterung des 3. Ventrikels bei raumfordernden Prozessen in der hinteren Schädelgrube. Aquaeduktverschlüsse weisen beispielsweise die stärkste Erweiterung auf, gefolgt von Kleinhirntumoren. Kleinhirnbrückenwinkeltumoren und Prozesse im caudalen Hirnstamm verursachen im allgemeinen eine deutlich geringere Dilatation der Ventrikel.

Bei starker Vergrösserung des 3. Ventrikels im Echogramm bei Kindern nehmen wir eine Ventriculographie vor. Besteht anamnestisch und klinisch begründeter Verdacht auf einen Aquaeduktverschluss, so bevorzugen wir jetzt statt eines Liquor-Luft-Austausches die Pantopaque-Ventriculographie. Diese hat den Vorteil, dass die röntgenologische Untersuchung in zeitlichem Abstand von dem operativen Eingriff und ohne Operationsbereitschaft durchgeführt werden kann. In allen übrigen Fällen folgt der Echoencephalographie die percutane Vertebralisangiographie. Die technische Durchführung wird durch Verwendung einer speziellen Punktionskanüle (siehe Abbildung), die vorn abgebogen ist und zirka 1,5 cm weit parallel dem Knochenkanal im Gefässlumen liegt, erleichtert. Postangiographische Schädigungen lassen sich durch eine Punktion zwischen dem 3. und 4. Halswirbel, eine dauernde Durchspülung des Systems während der Untersuchung sowie die strenge Vermeidung von Luftinjektion weitgehend ausschalten. Die Komplikationsrate liegt nach einer Zusammenstellung des uns zugänglichen Schrifttums um 6 %, doch ist dieser Wert aus später noch darzulegenden Grün-

RÉSUMÉ

L'association de l'écho-encéphalographie et des méthodes avec moyen de contraste améliore le diagnostic des lésions expansives de la fosse postérieure L'examen écho-encéphalographique par la mesure de l'élargissement du 3e ventricule permet de choisir la méthode avec moyen de contraste la plus indiquée le diagnostic définitif et les indications opératoires sont fournis dans la majorité des cas par l'angiographie vertébrale percutanée C'est seulement dans les obstructions de l'aqueduc et dans les tumeurs du tronc cérébral que la ventriculographie est la méthode de choix alors que les hématomes extra duraux de la fosse postérieure sont diagnostiqués grâce à l'angiographie carotidienne

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wohl die Vertebralisangiographie als auch die Encephalographie zur Diagnostik herangezogen, wobei letzterer oft die grössere Aussagekraft zukommt. Entsprechend der erst spät einsetzenden Passagebehinderung des Liquors im Bereich des Aqueduktes fehlt hier im Echoencephalogramm meist eine stärkere Erweiterung des 3. Ventrikels. Bei Pons- und Clivustumoren, die bei der temporalen Beschallung direkt vom Ultraschallbündel erfasst werden können, lassen sich aber gelegentlich Tumorechokomplexe im Echogramm nachweisen.

Im Gegensatz zu allen übrigen raumfordernden Prozessen in der hinteren Schädelgrube ist zum Erkennen epiduraler Hämatome die Carotisserienangiographie die Methode der Wahl. In der spätvenösen Phase kann dabei eine sichelförmige Abdrängung des Confluens sinuum von der Kalotte beobachtet werden (BEYER 1966).

Zusammenfassend möchten wir feststellen, das sich die Kombination von Echoencephalographie und Kontrastmittelmethoden zur Verbesserung der Diagnostik raumfordernder Prozesse in der hinteren Schädelgrube ausserordentlich bewährt hat, da auch in Fällen mit diskreter Symptomatik die Ultraschalluntersuchung sofort einen bereits vorhandenen Hydrocephalus aufdeckt und die weitere Diagnostik in die richtigen Bahnen lenkt.

ZUSAMMENFASSUNG

Zur Verbesserung der Diagnostik raumfordernder Prozesse in der hintern Schädelgrube hat sich die Kombination von Echoencephalographie und Kontrastmittelmethoden bewährt. Während die echoencephalographische Untersuchung durch die Messwertangabe der Erweiterung des 3. Ventrikels die Art der nachfolgenden Kontrastmittelmethode determiniert, werden endgültige Diagnose und Operationsindikation in den meisten Fällen durch die percutane Vertebralisangiographie gewonnen. Nur bei Aquaeduktverschlüssen und Hirnstammtumoren ist die Ventriculographie die Methode der Wahl, während epidurale Haematome der hinteren Schädelgrube durch die Carotisangiographie diagnostiziert werden.

SUMMARY

The diagnosis of expansive processes in the posterior fossa can be improved by the combined use of echoencephalography and methods of contrast medium injections. While echoencephalography will disclose the degree of dilatation of the third ventricle and indicate which contrast method may be adequately employed, a definite diagnosis and indication for operation are in most cases obtained by percutaneous vertebral angiography. Only in obliteration of the aqueduct and brain stem tumours is ventriculography the method of choice, while epidural haematomas of the posterior fossa are diagnosed by angiography of the carotid arteries.

RÉSUMÉ

L'association de l'echo-encephalcgraphie et des methodes avec moyen de contraste ameliore le diagno tic des lesions expansives de la fosse posterieure L'examen echo en cephalcgraphique par la mesure de l'élargi sement du 3e ventricule permet de choisir la methode avec moyen de contraste la plus indiquee le diagnostic définitif et les indications operato res sont fournis dans la majorité des cas par l'angiographie vertébrale percutanée C'est seulement dans les obstructions de l'aqueduc et dans les tumeurs du tronc cérebral que la ventriculo raphie e t la méthode de choix, alors que les hematomes extra duraux de la fosse posterieure sont diagnostiques grace a l'angiographie carotidienne

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THERMOGRAMME NORMAL DU CRANE

par

SERGIO DALBUONO et GIOVANNI RUGGIERO

En dehors de certains cas de thrombose de la carotide presentes par WOOD (1965), et GROS et coll (1967), les cas de thermogrammes pathologiques du crâne rapportes en litterature sont rares et montrent presque toujours des alterations peu considerables BACKLUND (1967) a examine, avec l'Aga Thermovision, 7 hematomes sous duraux et rapporte avoir observe, dans cinq cas, une zone froide en correspondance de la lesion Il en presente un (sans montrer l angiographie) dont l interpretation ne nous parait pas evidente Par contre, le tableau thermographique d un cas de meningiome est assez convaincant L auteur affirme que les meningiomes se traduisent par une zone chaude, mais il ne presente aucune analyse quantitative de ces resultats

Le but de ce travail est d attirer l attention sur ces artefacts et aussi de discuter le mecanisme avec lequel se produisent les differences de temperature

L examen thermographique du crane semble etre limite, pour la plupart des auteurs, a la projection antero-posterieure, doublee parfois d un profil

Or, a notre avis, il faut pratiquer un minimum de trois projections antero posterieure, profil droit, profil gauche, auxquelles, lorsqu on soupçonne une pathologie endocranienne, il faut ajouter une projection postero anterieure et une projection axiale supero inferieure (Fig 1) Nous sommes par ailleurs d accord avec BACKLUND pour raser au prealable les cheveux du malade

Une grande precision, comparable a celle de l examen radiographique, est necessaire En effet, de petites asymetries de position du crane peuvent donner

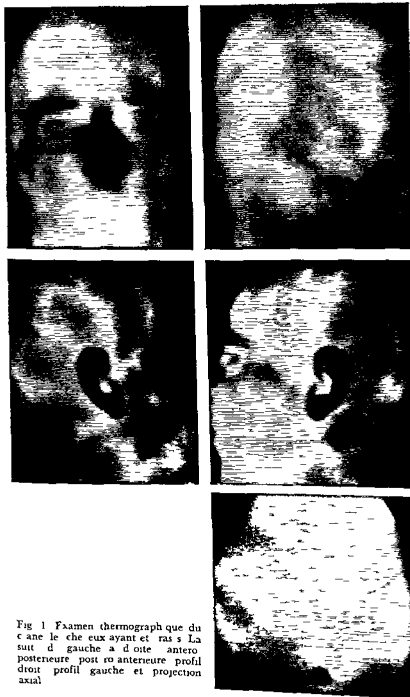


Fig 1 Fxamen thermograph que du c ane le che eux ayant et ras s La suit d gauche a d oite antero posterieure post ro anterieure profil droit profil gauche et projection axial



a b

Fig. 2 Aspect thermographique des cavites orbitaires avec les yeux ouverts (a) et avec les yeux fermes (b)

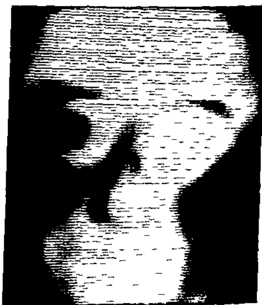


Fig 3 Thermographie dans un cas de paralysie faciale peripherique droite

des asymetries thermographiques (Fig 2) Par exemple, en projection antero posterieure, si la tete n est pas parfaitement droite on peut observer sur la convexite une bande chaude du côte oppose a celui vers lequel la tete est tournee A notre avis ceci peut être interprete par le fait que dans ce cas c est plutot la region frontale posterieure qui est analysee et que celle ci est, en general plus chaude

Nous avons etudie 30 thermogrammes normaux pour voir quelles sont les caracteristiques d un thermogramme normal du crane Les resultats dans 30 cas sont resumes ('chaleur marquee etant indiquee par ++, et chaleur moderee par +) dans le tableau, page 663

	Chaud	Froid
Cheveux		30
Front	28 ++ 2 +	
Nez	3 ++ 9 +	18
Région oculaire	24 ++ 6 +	
Pavillon auriculaire		30

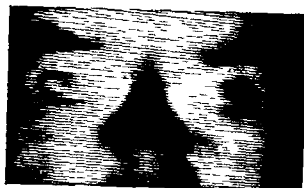
	Chaud	Froid
Lèvres	30 ++	
Joue	2 ++ 6 +	22
Cou	21 ++ 9 +	
Menton	1 ++ 16 ++	13

Il en résulte que les cheveux sont toujours froids ainsi que les pavillons auriculaires, alors que les lèvres sont toujours très chaudes. Le front, la région oculaire et le cou sont également chauds et même souvent très chauds. Le nez, les joues et le menton sont tantôt froids, tantôt chauds, plus souvent froids en ce qui concerne le nez et les joues, plus souvent chaud en ce qui concerne le menton.

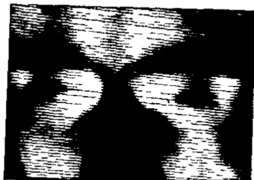
Il nous semble important d'établir, en présence d'une zone chaude, si la chaleur doit être rapportée à la surface ou à la profondeur. Si l'on examine, en effet, un sujet avec les yeux fermés, l'on voit apparaître au milieu des cavités orbitaires une zone froide, la ligne des cils. Par contre, si les yeux sont ouverts, une zone chaude apparaît au niveau des globes oculaires (Fig. 2). La question se pose si cette chaleur des globes oculaires soit intrinsèque ou due aux paupières qui les réchauffent par intermittence à travers le clignotement. Le cas illustré par la Fig. 3, une paralysie faciale périphérique, semble confirmer cette dernière hypothèse. En effet, la cavité orbitaire apparaît très froide du côté de la paralysie. Si le globe oculaire était intrinsèquement chaud, il n'y aurait pas de raison pour que la cavité orbitaire apparaisse froide quand, comme c'est le cas d'une paralysie périphérique, la fente palpébrale est plus ouverte que d'habitude.

On doit plutôt penser à l'action chauffante des paupières. Un autre mécanisme pouvant également être envisagé serait que le globe oculaire soit maintenu chaud par les larmes qui, dans le cas d'une paralysie faciale, s'évaporeraient à cause de la lagophtalmie.

Pour Wood, l'aspect chaud du front et des arcades orbitaires est fonction d'une vascularisation normale du territoire de l'artère ophtalmique, ce qui explique l'aspect typique de la thrombose de la carotide où la moitié du front apparaît froide. Le cas illustré par la Fig. 4 pourrait cependant faire reposer le problème.



a



b

Fig. 2. Aspect thermographique des cavités orbitaires avec les yeux ouverts (a) et avec les yeux fermés (b).

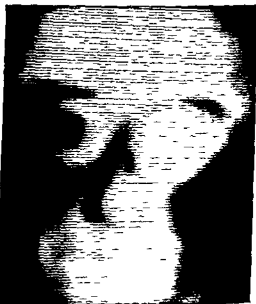


Fig. 3. Thermographie dans un cas de paralysie faciale périphérique droite.

des asymétries thermographiques (Fig. 2). Par exemple, en projection antéro-postérieure, si la tête n'est pas parfaitement droite, on peut observer sur la convexité une bande chaude du côté opposé à celui vers lequel la tête est tournée. A notre avis ceci peut être interprété par le fait que dans ce cas c'est plutôt la région frontale postérieure qui est analysée et que celle-ci est, en général, plus chaude.

Nous avons étudié 30 thermogrammes normaux pour voir quelles sont les caractéristiques d'un thermogramme normal du crâne. Les résultats dans 30 cas sont résumés ('chaleur marquée' étant indiquée par ++, et 'chaleur modérée' par +) dans le tableau, page 663.



Fig 5 Meningiome frontal posterieur de la convexite droite Une zone arrondie chaude est bien visible en projection axiale (b) et antero-posterieure (a) Sur cette derniere image on voit se diriger vers la tumeur une ligne chaude vraisemblablement l artere temporale superficielle hypertrophiee Celle ci est egalement bien evidente en projection laterale (c) ou la tumeur fait une bosse sur le profil de la voute cranienne Le diagnostic a ete confirme par l angiographie de l artere carotide interne et par l operation

d un cas de meningiome diagnostique par la thermographie ou justement le succes diagnostique nous parait fonction de la rigueur technique avec laquelle l examen a ete conduit ce cas est illustre par la Fig 5

RÉSUMÉ

Les auteurs presentent leur experience sur la thermographie du crane et de la face en mettant en evidence les modalites de l examen et les sources d erreurs techniques

SUMMARY

The authors present their experiences with thermography of the skull and face describing the method of examination and pointing to possible sources of error

ZUSAMMENFASSUNG

Die Erfahrungen der Verfasser mit Thermographie vom Schadel und Gesichte werden prasentiert *zusammen mit einer kurzen Beschreibung der Technik* Fehlerquellen sind erwahnt die moglicherweise in Betrachtung genommen werden sollten

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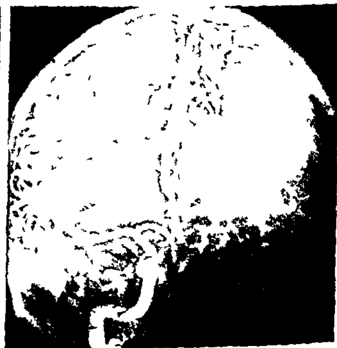
Wood E H Thermography in the diagnosis of cerebrovascular disease Radiology 85 (1965) 270



a



b



c

Fig. 4. Thrombose de l'artère carotide interne gauche au cou. a) Thermographie. b) Angiographie de la carotide *interne gauche*. Le contraste passe à contre-courant dans l'externe. c) Angiographie de la carotide *interne droite*. *Le contraste passe à contre-courant* dans l'artère cérébrale antérieure et dans les artères sylviennes gauches, mais non pas dans l'artère ophtalmique gauche. (L'artère ophtalmique droite est bien injectée.)

Il s'agit d'une thrombose de l'artère carotide *interne* gauche avec thermographie négative. Dans ce cas, l'angiographie controlatérale avait permis une excellente injection à contre-courant des branches intracraniennes de la carotide du côté de la thrombose, sauf l'artère ophtalmique qui n'était pas opacifiée.

Nous sommes en train de vérifier actuellement le rapport entre thermographie et angiographie, mais ceci, qui s'avère difficile étant donné la rareté des cas normaux avec angiographie carotidienne bilatérale, fera l'objet d'un prochain travail.

Enfin, il ne nous semble pas déplacé de conclure ce travail par la présentation

skull gives rise to the ophthalmic artery Carotid stenosis proximal to the origin of the ophthalmic artery could produce a reduction in skin temperature over the fronto-temporal area supplied by the ophthalmic artery

Lesions of the internal carotid artery distal to the bifurcation may be associated with an increase in blood flow in the external carotid on the same side and this might be detectable thermographically in the distribution of its facial branch When the internal carotid artery is occluded there is an immediate fall in pressure distal to the occlusion (BAKAY & SWEET 1952) and a rise proximal to the occlusion (STERN 1962) This rise is a general one and is probably accompanied by a fall in cerebro-vascular resistance since the blood flow in the contralateral carotid is increased (HARDESTY et coll 1961) This rise in blood flow might be reflected in a rise in skin temperature over the face and forehead on the unaffected side We have examined thermograms from 89 patients and attempted to interpret asymmetry in the thermal maps in the light of these anatomical considerations We have attempted to correlate these findings with the clinical picture and where justifiable with angiography

The Swedish Aga 652 Thermovision was used in this investigation The infrared radiation detector is an indium antimonide junction cooled by liquid nitrogen The signal developed varies with the intensity of radiation falling upon the detector and the area under examination is scanned by a system consisting of a moving mirror and a rotating prism The signal is amplified electronically and the picture displayed on an oscilloscope The oscilloscope screen may be photographed with a polaroid camera There is also the facility of demonstrating points of equal temperature thus producing isothermic recordings It is found to be more convenient to examine the patient supine using a polished steel mirror

Face and profile views were recorded together with isotherm photography as required A separate view was exposed of the cervical region The records were interpreted by two observers independently The results corresponded closely

Results

Thirty one of the patients had positive thermograms In fifteen of these patients the angiographic diagnoses were as follows carotid stenosis in ten patients vertebral disease in two aneurysm in one arterio-venous malformation of the scalp in one no abnormality in one In sixteen of these thirty-one patients no angiography was performed

In most of these the abnormality consisted of a cool area over the frontal area on one side and in ten of these there was marked involvement of the internal carotid arteries with either complete occlusion or a significant stenosis confirmed angiographically One patient had a severe stenosis of the common carotid artery

FROM THE DEPARTMENT OF MEDICAL NEUROLOGY, THE ROYAL INFIRMARY, UNIVERSITY OF EDINBURGH, SCOTLAND

VALUE OF THERMOGRAPHY IN INVESTIGATION OF CEREBRO-VASCULAR DISEASE

by

C MAWDSLEY, E SAMUEL, M D SUMERLING and G B YOUNG

There is good evidence of the value of anticoagulant therapy in patients who present clinically with transient ischaemic attacks (SICKERT MILLIKAN & WHISNANT 1961), and with strokes-in evolution (BAKER et coll 1962) Surgery is sometimes effective in the treatment of transient ischaemic attacks associated with stenosis of the internal carotid artery (DE BAKEY et coll 1962) A majority of patients with transient ischaemic attacks do not have extra cranial arterial stenosis (MARSHALL 1965) The diagnosis of the nature of extra cranial cerebro-vascular disease is thus of therapeutic importance, and is notoriously difficult on clinical grounds alone Percutaneous carotid angiography may be hazardous if the artery is atheromatous and although arch aortography may be safer its use should be selective A simple and safe technique for the assessment of arterial stenosis in the neck would have obvious usefulness It has been shown by WOOD (1965) that infrared thermography is a useful adjunct in the investigation of this type of problem

From a thermal map of the head and neck we can, in some cases make valid inferences about alterations in the blood flow in the cranial arteries Anatomical considerations suggest several ways in which disease of the carotid arteries might be reflected thermographically The internal carotid artery after entering the

Conclusions

From this preliminary survey we clearly can make only tentative conclusions. On the basis of our results it appears that localised cooling over the forehead in the region of distribution of the ophthalmic artery on the affected side is the most significant thermographic sign Asymmetrical thermal patterns over the face and neck arising from secondary changes in blood flow are less frequent, less reliable and difficult to interpret

Bilateral lesions are also difficult to interpret as in this method one relies on comparison of the heat pattern on the two sides of the face

Thermography gives a reliable pointer to the presence of occlusion or severe stenosis in the carotid arteries in the neck In all our patients with a completely occluded or severly stenosed carotid artery a diagnostic thermogram was obtained It is a much less useful tool for the assessment of minor degrees of carotid arterial narrowing This lack of sensitivity is not of serious therapeutic importance since only in major constrictive lesions would surgery be contemplated

Thermography was normal in patients with established infarcts without extracranial occlusion or stenosis

One of the most useful applications of the technique may lie in the differentiation of patients with extracranial cerebro-vascular disease from those with intracranial occlusion Our results suggest that if the thermogram be normal then angiography is not a justifiable procedure in the investigation of lesions in the carotid distribution If however there is significant thermal asymmetry over the forehead then angiography may be needed to distinguish between occlusions unhelped by operation and severe stenosis where surgery may be useful In the presence of disease of the vertebro-basilar circulation thermography is of little use and in this group the results were misleading

Finally it is noteworthy that patients who suffered from transient ischaemic attacks with no angiographic evidence of extracranial stenosis had normal thermograms Normal results on thermography in this group if consistently found would be of clinical use since again a normal thermogram would obviate the need for angiography Patients could be treated with anticoagulants without the need to search for a possible surgically remediable stenosis

In summary it seems likely that thermography offers a quick simple and safe screening procedure in patients with cerebro-vascular disease and may reduce the need to perform angiography and be helpful in the management of the patient

The presence of an increase in circulation through the external carotid artery on the affected side may be shown by one cheek being warmer than the other, by alterations in the heat pattern in the neck, or by an alteration in the heat pattern over the temple due to increased flow in the superficial temporal artery These patterns were, however, inconsistent and variable

No patient with a moderate or severe constriction of the internal carotid artery had a normal thermogram One patient with very slight narrowing of the carotid artery, due to an atheromatous plaque, demonstrated angiographically, had a normal thermogram One patient who had an intracavernous aneurysm of the internal carotid artery had a warm area over the orbit A positive thermogram was found in one patient who had a normal carotid angiogram, this represents our only false positive examination

In another sixteen patients who had positive thermograms angiography was not performed for various reasons In twelve of these patients there was localised cooling of the forehead suggesting diminished flow in the ophthalmic artery, and in four there was a warm area in the distribution of the facial branch of the external carotid Thus, in these sixteen cases, the thermographic picture suggested a carotid stenosis Although unconfirmed by angiography, in all these cases the suggested stenosis was compatible with the clinical features and in one patient the diagnosis of internal carotid stenosis seemed virtually certain on clinical grounds and was supported by ophthalmo dynamometry

Two patients had demonstrable lesions of the vertebral arteries In one patient, the stenosis was unilateral and in the other the lesion was bilateral The carotid arteries were normal in both These patients presented with hemiplegic episodes and each had an area of cooling over the side of the forehead on thermography In a third patient, who presented with the classical picture of a posterior inferior cerebellar arterial thrombosis the thermogram was normal

The remaining fifty eight patients presented a variety of clinical pictures angiographically there was no narrowing of the carotid arteries in 24 patients a minor carotid stenosis in one patient, and a cerebral tumour in one angiography was not performed in 32 of these fifty eight patients

Some of these were young people who had angiographic examinations to exclude aneurysms Others presented with an established cerebral infarct or generalised cerebro vascular disease and pseudobulbar palsy or transient ischaemic attacks

The importance of this group lies in the consistent normality of the thermograms, as in twenty six patients, angiography demonstrated no significant stenosis of the extracranial arteries

In the final group of thirty two patients, thermography was negative but angiography was not performed and this group will not be discussed further

FROM THE DEPARTMENT OF MEDICINE QUEEN'S UNIVERSITY, KINGSTON, ONTARIO
CANADA

ULTRASONIC ENCEPHALOGRAPHY

by

D N WHITE

Ultrasound like roentgen rays was first used in medicine as a transmission technique in an attempt to form images This year is the 25th anniversary of the first unsuccessful attempts by DUSSIK in Austria (1942) to produce images of the brain For ten years workers on both sides of the Atlantic struggled to develop this method until GUTTNER et coll (1952) showed that the enormous variations in the attenuation of the beam by the skull caused far greater changes in the ultrasonic field than any produced by the brain This problem appeared insurmountable and the technique was abandoned

It may be that further consideration should be given to the transmission technique In the field of electromagnetic energy the last few years have brought great developments in the imaging processes by recording the interference patterns formed by coherent light sources Ultrasonic transducers which unlike electromagnetic radiation sources readily produce coherent energy have been shown by THURSTONE (1966) to be able to produce images by the holographic technique It may be that in the next few years we shall see further development of this modification of the original transmission method If so we must expect a very different type of image from that obtained with roentgen rays which derive from a completely different form of energy Nor can one expect the images to resemble those evoked by ultrasonic echo techniques since the two techniques are as different as radiography is from photography

SUMMARY

Thermographic findings in eighty nine patients are reviewed Cooling of the forehead in the region of distribution of the ophthalmic artery is a good index to the presence of occlusion or stenosis in the common or internal carotid arteries Thermography is a valuable screening technique in the assessment of patients with cerebro vascular disease

ZUSAMMENFASSUNG

Eine Übersicht der Ergebnisse bei thermographischen Untersuchungen von 89 Patienten wird gegeben Kühlung frontal über die Regionen die von der Arteria ophthalmica versorgt werden ist ein zuverlässiges Zeichen von Obstruktion oder Stenose der A carotis communis oder der A carotis interna Thermographie dürfte eine wertvolle diagnostische Methode für die Untersuchung von Patienten mit cerebrovaskulären Erkrankungen sein

RÉSUMÉ

Les auteurs passent en revue les résultats de l'examen thermographique chez 89 malades Le refroidissement du front dans le territoire de distribution de l'artère ophtalmique est un bon signe d'obstruction ou de sténose des artères carotides primitive ou interne La thermographie est une technique de dépistage utile dans l'examen des malades atteints de troubles vasculaires cérébraux

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to the varying effect of the skull in deforming and attenuating the ultrasonic beam so that useful resolution is impossible (WHITE et coll 1967) That such degradation of information negates all our attempts to obtain a tomogram should remind us that the same degradation will also occur in A scans and we must be careful in reading an unwarranted degree of accuracy into our observations by this method

Nevertheless formidable as these difficulties are, there can be no doubt that both A and B-scans contain much useful information not all of which is obscured or malpositioned This important point can be appreciated from the linear B-scans made by GALICICH et coll (1965) who knowing the nature and position of the intracranial pathology was able with much patience and effort in some cases to produce images resembling the lesion known to be present This problem of extracting degraded information from a background of noise is one that engineers have had to face in many fields and surely it is to our engineering colleagues we must look for help in this formidable task

It would seem therefore that wherever we look in the field of ultrasonic encephalography we are at a most interesting and challenging point Both with transmission and reflection techniques we have reached an impasse where at the moment the skull too greatly degrades the useful information from the brain within The problem is whether this information can be extracted from this obscuring background and in a form that is useful In the years ahead these problems will surely pose one of the greatest challenges yet faced by the biophysical marriage

SUMMARY

Brief survey of the developments in ultrasonic encephalography

ZUSAMMENFASSUNG

Die Entwicklung von Ultraschallmethoden fur Encephalographie wird kurz besprochen

RÉSUMÉ

Le developpement des methodes ultrasoniques pour encephalographie est brievement decrit

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Although transmission techniques were the first to be used in medicine, all the progress that has been made in the field of applied medical ultrasonics so far has been due to the reflection or echo technique. It was a Frenchman who almost half a century ago first used the echo technique when LANGEVIN (1918) developed an echo ranging technique for the detection of submerged submarines from which eventually the Sonar system was evolved. FIRESTONE (1940) further developed the reflection technique for industrial purposes during the Second World War. Most of the early work in this field was carried out after 1950 by WILD (1950) in the U S, usually on soft tissue such as the breast. In the middle fifties the group at Lund applied the technique first to the heart and then to the intact head. Although the potential rewards for ultrasonic brain scans far exceed those for successful examination of other parts of the body, little progress has been made in the last decade in the realm of echo encephalography. It is true that it is now possible to demonstrate the cerebral mid line with a fair degree of accuracy but, with the exception of the lateral ventricular echoes in cases of hydrocephalus, especially in children, few other intracranial measurements can reliably be made. The cerebral A scan has not developed commensurately with its great progress in the fields of cardiology and ophthalmology.

However, as a by product of the cerebral A scan, and no doubt inspired by the work of EDLER (1955) in recording the movement of echoes from the heart valves, we have seen in recent years an increasing interest in the nature of the pulsation of the intracranial echoes. In recording these pulsations we are faced with formidable difficulties in instrumentation, which seem best to have been recognised by JEPPSSON (1964), another of the original group from Lund who did so much, 14 years ago, to develop the echo technique. Both JEPPSSON and DE VLIEGER (TER BRAAK et coll 1965) have clearly shown the influence of intracranial pressure on the rise time of the echo pulsations, while MCKINNEY (1967) in his pioneer work showed how they are influenced by other physiologic variables.

As soon as the amplitude modulated A scans had been shown to contain information of value it was natural for the bio physicists to emulate their colleagues in radar engineering and construct B and C scan devices. HOWRY & BLISS in 1952 published the first tomogram of soft tissue, and six years later DONALD & BROWN (1961) developed this technique for the investigation of gynaecologic disorders with such success that the early sixties saw an unprecedented rush to develop B scanners for the brain, since, if it were possible equally easily to produce tomograms of the brain, the benefits would result in a major step forward for neurology.

However, no successful tomograms have yet been developed and it would seem that this failure, like the failure of the transmission method, also might be due

FROM THE DEPARTMENT OF NEUROLOGY (DIRECTOR D N WHITE) QUEEN S UNIVER SITY, KINGSTON, ONTARIO CANADA

AMPLITUDE AVERAGED ECHOENCEPHALOGRAPHY

Scope and limitations

by

D NALDRETT WHITE

It is over ten years since A scan echoencephalography was first described It is now possible to state that it provides a quick cheap and safe method of deter mining the position of the cerebral midline structures in the region of the posterior part of the third ventricle Nevertheless its adoption has not been widely accepted despite the fact that almost all investigators have claimed an accuracy of over 90 % for the test Such an accuracy would compare favorably with roentgen examinations and thus it seems strange that echoencephalography has not been more widely accepted and used

The reason for this anachronism in our opinion is that the examination itself is not so accurate as these figures would suggest Up to the present echoen cephalography has usually been carried out by medical specialists such as neurologists neurosurgeons or radiologists who might be expected to learn from the patient s history or appearance or what they have heard regarding the patient s investigation whether or not deforming intracranial disease was present Since the identification of the M-echo from all the other echoes displayed from within the skull is partially subjective it is not unreasonable to expect that any preconceived ideas that the operator may have formed regarding the position of the M-echo could bias the results of the test It is for this reason we believe that

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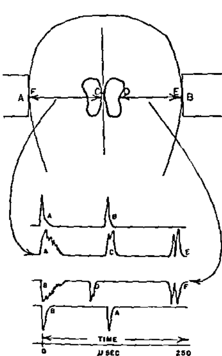


Fig 3

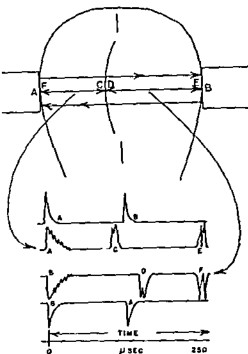


Fig 4

Fig 3 The two echo traces show that the echo evoked by each is not from one structure since the echo deflections neither lie along the intersection of the transmission pulses (B A) nor lie symmetrically to either side of the intersection (fig 4)

Fig 4 A mid line shift with symmetrical displacement of the M echo deflections (C D) to either side of the line joining the two transmission pulses (B A)

(White & Blanchard 1966) We try to obtain better objectivity and freedom from bias by averaging all the intracranial echoes over a period of one minute with a time exposure Since the M-echo is usually of greater stability and higher amplitude than any other intracranial echo it can then be identified by the fact that its time averaged presentation is more intense and of higher amplitude than any other echo This technique unfortunately sacrifices the other characteristic of the M-echo which allows the skilled operator often to identify it namely its characteristic two- or three peaked shape

It has also been our opinion that the technique must be modified to one that can be carried out by relatively unskilled personnel It would not appear that the limited information that the test provides justified the expenditure of the time of such highly skilled specialists as neurologists radiologists or neurosurgeons

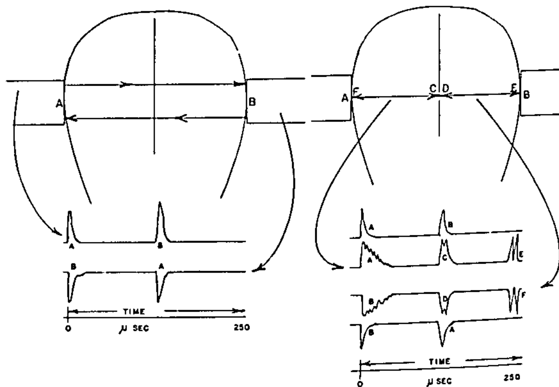


Fig 1 Fig 2

Fig 1 Transmission pulses passing one way across the skull from one transducer to the other take the same time as an echo pulse travelling from one transducer to the true mid line and back to the original transducer (fig 2)

Fig 2 Transmission pulses (top and bottom traces) mark the position of the theoretical mid position between the two transducers Here the two echo traces (middle traces) show M echo deflections at the same position along the time base as the mid point between the transducers A—left hand transducer B—right hand transducer C—M echo from left hand transducer D—M echo from right hand transducer E—far side echo from left hand transducer F—far side echo from right hand transducer

claims of 90 % or higher accuracy for echoencephalography are exaggerated and do not properly represent the accuracy of the technique itself but rather a combination of the clinical skill and knowledge of the operator combined with the use of this technique

Amplitude averaged technique

For the past several years we have endeavoured to develop a modification of the technique that will enable the M echo to be distinguished from all the other intracranial echoes in an objective and graphic and reproducible manner We first described our method at the last Symposium in New York three years ago

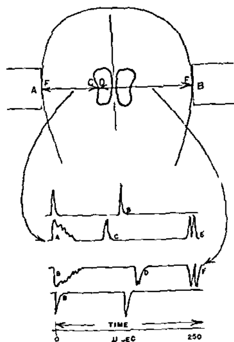
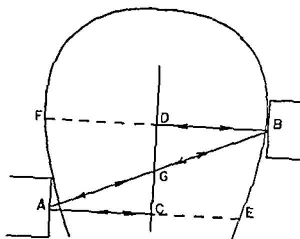


Fig 7 If both echo pulses are recorded from the same structure which is not part of the mid line complex a false shift of the mid line might be diagnosed

echoencephalographs Each pair of traces uses the left hand transducer as a transmitter for the upper traces and the right hand transducer as a transmitter for the two lower traces the transmission pulse traces being at the top and bottom of the photograph with the echograms in the centre

The advantage of using transmission pulses in each photograph is that they mark readily and unmistakably the position of the theoretical mid point between the transducers since the time taken for a pulse to travel one way across the skull is the same as the time taken for a pulse to reach the mid line and be reflected back to the transmitter receiver (Fig 1) Thus, in any case in which the mid line structures are not displaced the M echoes from them will lie in the same line as the line intersecting the onset of the two transmission pulses always provided that in every case the initial echoes from the crystals are in all four traces accurately aligned above each other (Fig 2)

It will be seen that the advantage of this method is that it should show definitely whether two echoes on the middle traces are coming from one and the same object If the echo on one side was recorded from a lateral ventricle or other structure and on the other side from the mid line this would be immediately apparent (Fig 3) because while the lower trace shows an echo displaced towards



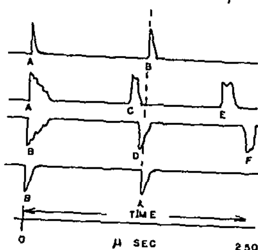
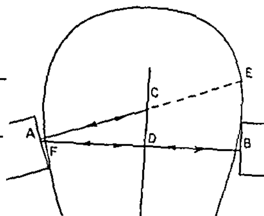


Fig 5



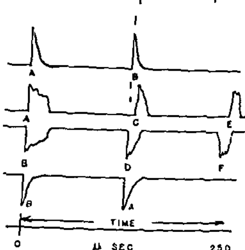


Fig 5

Fig 5 Non homologous placement of the transducers is apparent not only by incongruity of the M echoes (C D) with respect to the transmission pulses (B A) but more markedly by the absence of superimposition of the far side echo pulses (E F)

Fig 6 Misalignment of the transducers again shows incongruity of C D with respect to B A and also lack of superimposition of the far side echoes (E F)

Radiology would never have developed to its present state if every radiogram had to be taken by the physician himself or even by the radiologist

The amplitude averaging technique partially achieves these twin objectives of providing a more objective, reproducible graphic presentation capable of being interpreted by any observer and which can be performed by relatively unskilled technicians

The technique that we have evolved so far but which we are continuing to modify, has been described elsewhere (see references) Briefly, each photograph of our scan consists of four traces, two of which are transmission pulses and two

Table 1

Summary of results in a total of 484 examinations (all percentages are approximated)

Unsatisfactory echograms		Predicted					
		No shifts			Shifts		
		Correct		Errors	Correct		Errors
50		405		0	21		8
10	of total	100	of group	0	70	of group	30

Table 2

Echoencephalographic results in comparison with radiologic indications

Echograms	Radiologic findings	
	Without shifts	With shifts
Unsatisfactory	35 (8)	15 (40)
Correct	405 (90)	21 (60)
Erroneous	8 (2)	0

The presentation system is monitored onto a second oscilloscope on which a camera is mounted The examination is carried out in four stages. Firstly with the two transducers applied to the skull just behind the vertical line passing through the front of the pinna and at a level just above the pinna the echoes from the *left hand transducer are displayed and a* time-exposure made for one minute Then the inverted echoes from the right hand transducer are displayed and photographed on the same film for another minute Finally, the transmission pulses first from left to right and then from right to left transducers are displayed and photographed all on the same film All four traces are made without moving the transducers the different presentations and operation of the camera being carried out by foot switches

The polaroid photograph is then immediately developed and examined by the operator to see if it fulfills the criteria that we consider are necessary before it is accepted as a satisfactory *echogram These criteria are* first, all four initial crystal deflections must be aligned secondly the echoes from the far side of the skull *in the two echo traces* must be superimposed thirdly the M-echo deflections must (1) be of adequate amplitude and sharpness with a clean take-off from the

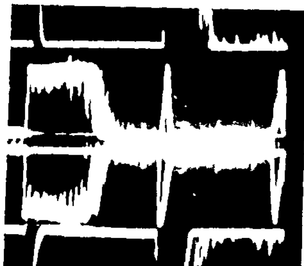


Fig 8 A typical amplitude averaged A-scan echoencephalogram with the two M echoes of very much higher amplitude than any other intracranial echoes Alignment of the initial deflections and far side skull echoes Since the M echoes both lie at the same distance along the time base as the transmission pulses (top and bottom traces) they must originate from the mid line

the transducer, that on the upper trace shows an echo in the mid line Therefore, they cannot be coming from the same structure On the other hand, if the mid line is displaced (Fig 4) and echoes are obtained from it on either side, this will be at once apparent by showing a shift of the two traces by an equal amount to either side of the intersecting transmission pulses

This technique would appear not only to prevent erroneous readings due to each transducer receiving echoes from different structures, as noted above, but also to prevent two other errors which have often been blamed for mistaken positioning of the mid line If the transducers are not applied to homologous areas of the skull (Fig 5), the mid line may appear at different distances from each owing to the difference in breadth of the head at two points Although such a mistake will show a displacement of the M echoes, the non validity of the traces is immediately apparent when it is noted that the far side echoes from the two sides are at different distances along the time base In the same way if the transducers while applied to homologous areas are misaligned (Fig 6), not only will the farside echoes not be superimposed but also the two M echoes will neither lie on the line intersecting the transmission pulses nor lie symmetrically to either side of this line

Indeed, there would appear to be only one possible source of error with this technique, as shown in Fig 7, where both transducers record echoes from an identical reflecting surface which is not part of the mid line structures Experience has shown us that this error is only likely to occur in cases of dilatation of the third ventricle due to internal hydrocephalus It is indeed the reason for almost all of the false positive errors that result from this technique

Results

So far the technique has been used in over 3 000 clinical examinations In order to evaluate its accuracy we have also examined 484 consecutive cases in which subsequent encephalograms or angiograms were obtained so that the true position of the mid line structures could be verified In no case was the echogram performed after radiography, lest knowledge of the findings in the radiographic examinations should bias our operators It is for this reason that the number of cases showing shifted mid lines is small, since often these cases were admitted to hospital as emergencies and roentgenography was performed before we could examine the patient ultrasonically The position of the mid line was determined by the posterior part of the third ventricle or the internal cerebral vein and where the roentgenograms did not satisfactorily display these structures the cases were discarded

The results are summarised in Table 1 From this it will be seen that the technique appears to have one rather important advantage So far it has made no false negative errors No test can ever achieve perfection but it seems that our technique is heavily biased against making false negative errors at the expense of making some false positive errors It would seem that even if taken alone these results show one important advantage Apparently if with our technique the echogram shows no shift of the mid line structures we are hardly ever *wrong* Thus in 405 cases out of the total of 484 the ultrasonic examination itself would have been able to assure the patient s physician of the normality of the mid line structures with considerable reliability and thus might have saved the patient the need for encephalography or angiography

Moreover even though one third of all shifts predicted by our technique were shown to be errors and this percentage may seem unduly high investigation has shown that in all these falsely thought to have shifted mid lines the error was due (Fig 7) to the maximal amplitude echo being recorded by both transducers *from one wall* of the third ventricle Thus since no shift of less than 3 mm was considered significant in all such cases the third ventricle was over 6 mm in width In other words all these cases of false positive errors *proved* on investigation to have no shift of the mid line structures but internal hydrocephalus instead Thus although we do not wish to discount these errors the error is rather less serious if it occurs only in cases of intracranial disease albeit not deforming intracranial disease Moreover considered as a *proportion* of the whole group the percentage of false positive errors is only 2 % as shown in Table 2

A more serious defect of the technique would seem to be the high percentage of cases with deforming intracranial disease in which a satisfactory echogram could not be obtained (Table 2) *In over 40 %* of patients with shifted mid lines no

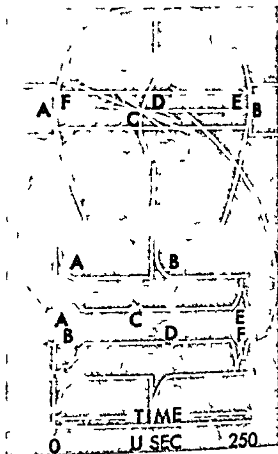


Fig 9 In cases of deforming intracranial disease the mid line structures are distorted from their normal position perpendicular to the ultrasonic beam and hence no longer return strong echoes by specular reflection to the active transducer

baseline to allow their clear identification, (2) lie either in the line intersecting the two transmission pulses or symmetrically to either side of it (Fig 8) If the photograph does not fulfil all of these criteria, the examination is immediately repeated until a satisfactory picture is obtained It is for this reason that we use polaroid film so that no delay occurs in repeating an unsatisfactory examination

It will be noted that we display the echoes from each side separately and not simultaneously, as could easily be done We do this in order to try to reduce operator bias since we found that when the echoes from both sides were displayed simultaneously, the operator often tried to manipulate the transducers so that the high amplitude echoes lay directly above and below each other as they do when both arise from undisplaced mid line structures We wanted our operators to elicit the most persistent maximal amplitude echoes no matter where they lay along the unmarked time base Only thus did we feel it was possible to make the technique more objective and less prone to operator bias

eines internen Hydrocephalus kann jedoch die Methode dadurch dass die eine Wand des dilatierten dritten Ventrikels fehlerhafterweise als Mittellinie gedeutet wird, falsche positive Fehler geben in beinahe der Hälfte aller Falle mit einer verschobenen Mittelinienstruktur konnten keine zufriedenstellenden Echogramme erhalten werden.

RÉSUMÉ

L auteur appelle amplitude averaged echoencephalography une photographie de l oscilloscope echoencéphalographique faite avec un long temps de pose Cette methode fournit une photographie aisement interpretable qui montre la position des structures de la ligne mediane du cerveau Elle est moins sujette a l erreur personnelle de l observateur que d autres methodes et peut etre employee par un personnel relativement peu entraine Sur 484 cas consecutifs qui ont tous ete verifies par encephalographie ou par angiographie cerebrale il n y a pas eu de resultats faussement negatifs Cependant dans des cas d hydrocephalie interne cette technique peut donner des resultats faussement positifs en identifiant a tort une paroi du troisieme ventricule dilate comme etant la ligne mediane et dans pres de la moitie de tous les cas ou il y avait un deplacement des structures de la ligne mediane il a ete impossible d obtenir des echoencephalogrammes satisfaisants

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echogram could be obtained that fulfilled our criteria for a satisfactory examination. It will be remembered that the technique depends for its performance upon the M echo causing the highest amplitude reflection of all the intracranial echoes and that this highest amplitude is presumably due to specular reflection from the various plane interfaces in the mid line which are perpendicular to the beam traversing the bitemporal axis. In deforming intracranial disease this perpendicular relationship of the mid line interfaces to the beam will be distorted and destroyed so that specular reflection will no longer return high amplitude reflections to the active transducer (Fig. 9). Under these circumstances the mid line structures will return echoes of no higher amplitude than the other intracranial structures and hence be indistinguishable from them.

Despite these defects the techniques would seem to have worthwhile advantages. Particularly if it can be relied upon to give no or very few false negative errors it would seem to be well adapted as a screening test. In such circumstances the finding that there was no shift of the mid line structures as would occur in the vast majority of a random population could be taken as reliable. Such information could be of considerable value to the clinician.

Acknowledgement

This work was supported by grants from the Medical Research Council of Canada. The film illustrating the technique was produced with the financial assistance of the Ontario Mental Health Foundation.

SUMMARY

Time or amplitude averaged echoencephalography provides an easily interpreted echogram showing the position of the cerebral mid line structures. The technique is less liable to cause observer bias than other methods and can be used by relatively unskilled personnel. In 184 consecutive cases all subsequently verified by encephalography or cerebral angiography no false negative errors were made. However in cases of internal hydrocephalus it may give false positive errors by falsely identifying one wall of the dilated third ventricle as the midline. In nearly half of all the cases with displaced midline structures satisfactory echograms could not be obtained.

ZUSAMMENFASSUNG

Die Zeit- oder Amplituden-gemittelte Echoencephalographie liefert ein leicht zu deutendes Echogramm, das die Lage der cerebralen Mittellinienstrukturen zeigt. Die Technik ist weniger als andere Methoden von der persönlichen Voreingenommenheit des Beobachters abhängig und kann von einem relativ unerfahrenen Personal angewandt werden. In 184 aufeinanderfolgenden Fällen, die alle hinterher durch Encephalographie oder cerebrale Angiographie erhärtet wurden, wurden keine falschen negativen Fehler gemacht. In Fällen

Tableau 1

Caractéristiques physiques des principaux contrastes liposolubles

Produit	Densité à 15	Opacite en gramme d iode/ml	Viscosite (en poises)
Lipiodol Lafay	1 36	0 54	20
Lipiodol F	1 32	0 52	2
Lipiodol UF	1 28	0 48	0 65
(Eth odol)			
Pantopaque	1 23	0 38	0 60
(Myod l Eth odan)			
D col piodol	1 15	0 32	0 25
Durollopaque	1 14	0 32	0,28

Le Lipiodol ultrafluide est 3 fois plus fluide que le precedent pour une opacite tres voisine Il peut en principe etre reponctionne apres l examen mais il faut reconnaitre qu en realite cette ponction n est pas tres facile

Le Pantopaque ou Myodil est certainement le produit le plus utilise actuel lement Legerement moins opaque que le Lipiodol ultrafluide, il a sensiblement la meme fluidite que lui Il est facilement reponctionne apres l examen ce qui a evidemment grandement contribue a son succes Quant au probleme de sa toxicite il a fait couler beaucoup d encre Pour certains le Pantopaque est moins toxique que le Lipiodol Pour d autres il l est davantage Disons simplement a ce sujet que tous les travaux se referent au vieux Lipiodol et que nous n avons trouve aucun travail dans la litterature comparant le Pantopaque au Discolipio dol

Le Discolipiodol est le grand meconnu de la serie il est plus de 2 fois plus fluide que le Pantopaque son retrait apres l examen est facile et paradoxalement il parait assez peu connu C e t lui que nous utilisons depuis plusieurs annees pour toutes nos myelographies a contraste positif

Enfin arrive le Durollopaque Son opacite et sa fluidite sont sensiblement les memes que celles du Discolipiodol

Etude pharmacologique

L etude pharmacologique de ce nouveau produit a ete presentee par GUERBET (1966) a la Societe Française de Therapeutique

D apres cet auteur la toxicite aigue per os du Durollopaque ne peut pas etre determinee avec precision puisqu il faudrait des doses trop importantes La dose

SPINE INCLUDING ANGIOGRAPHY AND MYELOGRAPHY

MONO-IODO-STEARATE D'ETHYLE ET MYELOGRAPHIE

par

J Bories Ch Bamberger Bozo et J Rosier

Nous avons experimente un nouveau produit de contraste pour myelographie, le Durolioptaque Sur le plan chimique, il s agit du mono-iodo stearate d ethyle pur, *dont la teneur en iode est de 0,32 g/ml* Sur le plan physique c est un liquide huileux, insoluble dans l eau et dans les liquides *organiques*

Nous avons resume ses principales caracteristiques physiques dans le Tableau 1, qui permet de les comparer a celles des autres produits existant actuellement sur le marche

Sur ce tableau, les *produits sont* classes par ordre de viscosite decroissante

En tete, nous trouvons l ancetre le vieux Lipiodol Lafay C est a lui que nous devons les premieres explorations du canal rachidien Mais c est a lui que nous devons egalement la plupart des travaux sur les dangers du Lipiodol et la mauvaise reputation qu a ce produit dans de nombreux services Il est extremement epais puisque sa viscosite est de 20 poises, et n a plus aucun interet aujourd hui en neuroradiologie

Ensuite vient le Lipiodol fluide, qui est 10 fois plus fluide que le precedent pour une opacite pratiquemment identique Il n a pourtant que des inconvenients par rapport aux produits suivants et l on comprend mal pourquoi il est encore utilise dans certains services

DEPARTMENT DE NEURO RADIOLOGIE (PR AGR J BORIES) DE LA CLINIQUE DES MALADIES DU SYSTEME NERVEUX (PROF P CASTAIGNE), HÔPITAL DE LA SALPETRIERE, PARIS, FRANCE

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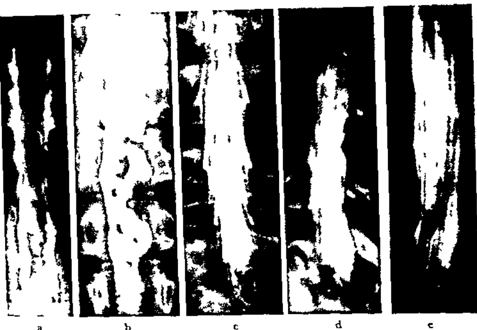


Figure 1 a) Region cervico dorsale normale b) Angiome de la region dorsale inferieure c) et d) Cas normaux examines avec du Durollopaque emulsionne cliche de face (c) et incidence de 3/4 (d) e) Hernie discale L3—L4 cliche de face Arret complet du contraste en L3—L4

malades qui avaient reçu du Discolipiodol deux nous ont ete signales l un avait presente une reaction meningee assez importante l autre des douleurs radiculaires

Pendant la deuxieme periode de notre experimentation tous les malades ont reçu du Durollopaque Ce deuxieme stade comprend 34 malades dont les suites sont resumees dans Tableau 2

Aucun malade n a presente de reactions meningees Trois se sont plaints de rachialgies ou de douleurs radiculaires Dans un cas il s agissait de douleurs cervicales qui ont persiste jusqu a l intervention le deuxieme jour apres l examen dans un autre cas il s agissait de lombalgies qui ont disparu spontanement au bout de 48 heures Le troisieme malade enfin a souffert de douleurs dans les membres inferieures qui ont persiste jusqu au retrait du contraste le quatrieme jour apres l examen

Quatre malades sur 34 se sont plaints de cephalees Celles-ci n ont jamais persiste plus de deux jours

Chez 11 malades sur 34 l examen a ete suivi d une poussee thermique Dans

Tableau 2

Suites de l'examen avec le Duroliopaque

	Poussée thermique le 2e jour	Douleurs radiculaires	Céphalées	Réaction méningée
Nombre de malades (sur 34)	11	3	4	0

léthale 50 chez le rat est supérieure à 20 g/kg, alors qu'elle est de 2,1 g/kg avec l'antopaque.

Dans le même travail, GUERBET rapporte le résultat de l'expérimentation par voie sous-arachnoïdienne chez le chien. Cette étude, faite parallèlement pour le Duroliopaque et le Pantopaque a montré que pendant les 48 heures suivant l'injection, tous les chiens ayant reçu du Duroliopaque ont présenté une légère raideur de la nuque sans autre manifestation clinique. Tandis que les chiens ayant reçu du Pantopaque présentaient une réaction méningée importante avec fièvre, et, chez deux d'entre eux, parésie transitoire des membres inférieurs.

D'après cette étude, le Duroliopaque est donc indiscutablement mieux toléré que le Pantopaque.

Cependant, l'étude histologique des moelles des chiens après des périodes de 1 à 14 mois après l'injection a montré que certains animaux présentaient des déformations radiculaires avec lésions des gaines, et que plusieurs d'entre aux présentaient des lésions médullaires du même type que celles que l'on observe avec les autres contrastes liposolubles, et ceci sans qu'il n'y ait aucune relation entre la quantité de produit injectée et l'existence ou non de ces lésions.

Cela montre l'importance de retirer le produit après l'examen.

Étude clinique

Sur le plan clinique, nous avons utilisé le Duroliopaque chez 64 malades de 28 à 69 ans.

Pendant une première période, nous n'avons utilisé le Duroliopaque que chez certains malades et nous avons demandé aux cliniciens, qui savaient que nous expérimentions un nouveau produit, mais ignoraient lequel avait été utilisé chez leur malade, de nous signaler toutes les suites inhabituelles qu'ils pourraient observer.

Trente malades ont reçu du Duroliopaque pendant cette période. Un seul parmi eux nous a été signalé : il avait présenté après l'examen des douleurs radiculaires importantes, qui ont disparu après le retrait du contraste. Parmi les

Chez les quelques patients pour lesquels nous avons utilise cette technique nous n avons pas observe de reactions plus violentes que chez les autres malades Cela parait en contradiction avec les travaux de JAEGER (1950) chez le chien Mais il est probable comme le pensent PORTERA (1966) et PENNING (1966), que les accidents de JAEGER sont dus a ce que cet auteur utilisait une emulsion stable et a particules tres fines, le stabilisateur etant de la poudre d acacia

L emulsion que nous avons utilisee est au contraire tres grossiere et de vie tres breve puisque dans tous nos cas elle etait rompue 24 heures apres l examen

Cette technique permet d obtenir des images extremement fines qui rapellent celles que l on obtient avec les hydrosolubles du types Methiodal ou Kontrast U mais avec un contraste tres superieur (Figs 1c, 1d, 1e et Figs 2 et 3)

Lorsque l emulsion est rompue le contraste peut etre retire, comme apres une myelographie ordinaire

Conclusion

Le Duroliopaque nous parait un produit extremement interessant Moins toxique que le Pantopaque chez l animal, il est plus de deux fois plus fluide que ce produit Il se retire facilement apres l examen et peut etre utilise en emulsion La tolerance chez les malades est excellente

Toutefois il importe de souligner en ce qui concerne la tolerance que si nous n avons observe aucune complication dans notre materiel il est trop tot pour savoir ce que pourraient etre les complications tardives lorsque le produit est laisse en place Mais les resultats de l experimentation animale permettent de penser qu il est certainement preferable de reponctionner le produit apres l examen

RÉSUMÉ

Les auteurs ont experimente un nouveau produit de contraste liposoluble le mono-iodo stéarate d ethyle commercialise sous le nom de Duroliopaque Le produit a des caracteristiques physiques sensiblement identiques qu celles du Discolipiodol Il est plus de deux fois plus fluide que le Pantopaque pour une opacite sensiblement identique et beaucoup moins toxique chez l animal que ce dernier produit Il se reponctionne facilement apres l examen et peut etre utilise en emulsion dans le liquide cephalo rachidien pour l exploration du cul de sac lombaire Enfin ce produit est tres bien tolere par les malades Le recul n est pas suffisant pour savoir ce que pourraient etre les complications tardives eventuelles mais les auteurs pensent a ce sujet qu il est préférable de ne pas laisser le produit en place apres l exam n



Fig. 2. Clichés obliques droit et gauche. Volumineuse hernie discale L5—S1 droite.



Fig. 3. Clichés face (a) et oblique (b). Hernie discale L5—S1 gauche.

un cas, celle-ci a atteint 39°. Dans dix autres cas, elle était autour de 38°. Elle n'a jamais duré plus de 24 heures.

Au total, toutes ces suites sont assez banales, la plupart peuvent se voir après une simple ponction lombaire, et le Duroliopaque apparaît comme un produit très bien toléré.

Technique

Sur le plan technique, les clichés obtenus avec le Duroliopaque sont excellents et absolument comparables à ceux que l'on obtient avec le Discolipiodol (Fig. 1, a et b).

Le Duroliopaque est facilement reponctionné après l'examen.

Enfin, un autre avantage de ce produit est qu'il est facile de l'émulsionner.

Nous n'avons encore examiné qu'un petit nombre de malades avec cette technique, déjà utilisée par Bleasel (1961) et Portera (1964, 1966) avec le Pantopaque, et nous n'avons utilisé cette méthode que pour examiner la région lombaire dans des cas de sciatique. Nous mettons dans une seringue stérile munie d'un robinet, 5 ml de Duroliopaque, 5 ml de liquide céphalo-rachidien du malade et quelques millilitres d'air. Puis nous agitons fortement à la main et injectons immédiatement l'émulsion ainsi obtenue.

Chez les quelques patients pour lesquels nous avons utilise cette technique, nous n avons pas observe de reactions plus violentes que chez les autres malades Cela parait en contradiction avec les travaux de JAEGER (1950) chez le chien Mais il est probable, comme le pensent PORTERA (1966) et PENNING (1966) que les accidents de JAEGER sont dus a ce que cet auteur utilisait une emulsion stable et à particules tres fines, le stabilisateur etant de la poudre d acacia

L emulsion que nous avons utilisee est au contraire tres grossiere et de vie tres breve puisque dans tous nos cas *elle etait rompue 24 heures apres l examen*

Cette technique permet d obtenir des images extremement fines qui rapellent celles que l on obtient avec les hydrosolubles du types Methiodal ou Kontrast U mais avec un contraste tres superieur (Figs 1c 1d 1e et Figs 2 et 3)

Lorsque l emulsion est rompue le contraste peut etre retire, comme apres une myelographie ordinaire

Conclusion

Le Durohopaque nous parait un produit extremement interessant Moins toxique que le Pantopaque chez l animal il est plus de deux fois plus fluide que ce produit Il se retire facilement apres l examen et peut etre utilise en emulsion La tolerance chez les malades est excellente

Toutefois il importe de souligner en ce qui concerne la tolerance que si nous n avons observe aucune complication dans notre materiel il est trop tot pour savoir ce que pourraient etre les complications tardives lorsque le produit est laisse en place Mais les resultats de l experimentation animale permettent de penser qu il est certainement preferable de reponctionner le *produit apres* l examen

RÉSUMÉ

Les auteurs ont experimenté un nouveau produit de contraste liposoluble le mono-iodo stearate d ethyle commercialise sous le nom de Durohopaque Le produit a des caracteristiques physiques ensiblement identiques que celles du Discolipiodol Il e t plus de deux fois plus fluide que le Pantopaque pour une opacité sensiblement identique et beaucoup moins toxique chez l animal que ce dernier produit Il se reponctionne facilement apres l examen et peut etre utilise en émulsion dans le liquide cephalo-rachidien pour l exploration du cul de sac lombaire Enfin ce produit est tres bien tolere par les malades Le recul n est pas suffisant pour savoir ce que pourraient etre les complications tardives eventuelles mais les auteurs pensent a ce sujet qu il est preferable de ne pas laisser le produit en place apres l examen

SUMMARY

The authors have developed a new liposoluble contrast medium (ethyl mono iodo stearate), marketed as Duroliopaque having physical characteristics closely resembling those of Discolipiodol The new medium while producing a similar contrast density is more than twice as fluid and much less toxic in animals than Pantopaque Duroliopaque can easily be aspirated after the examination and may be used as an emulsion in the cerebrospinal fluid for examination of the lumbar region Though Duroliopaque seems to be well tolerated by the patient it has not been in use long enough to know whether any late sequelae may occur It is recommended not to leave the contrast medium in place after the examination

ZUSAMMENFASSUNG

Die Autoren haben ein neues fettlosliches Kontrastmittel (Ethyl Mono Jodo Stearat) marktgefuhrt unter dem Namen Duroliopaque entwickelt dessen physikalische Eigenschaften denen des Discolipiodol sehr ahnlich sind Wahrend das neue Kontrastmittel eine ahnliche Kontrastdichte hat ist es zweimal flussiger und sehr viel weniger toxisch im Tierversuch als Pantopaque Duroliopaque lasst sich ohne Schwierigkeiten nach der Untersuchung aspirieren und kann als eine Emulsion mit der Ventrikel Flussigkeit zur Untersuchung des Lumbalsacks verwendet werden Obwohl Duroliopaque sehr gut vom Patienten vertragen zu werden scheint ist es noch nicht lange genug im Gebrauch um zu wissen ob irgendwelche spate Folgeerkrankungen auftreten konnen Die Autoren empfehlen daher das Kontrastmittel nach der Untersuchung nicht am Platze zu lassen

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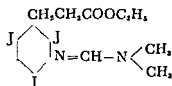
CLINIQUE NEUROCHIRURGICALE (DIRECTEUR PROF K SCHURMANN) ET L INSTITUT DE RADIOLOGIE (DIRECTEUR PROF L DIETHELM) DE L UNIVERSITE DE MAYENCE, MAINZ ALLEMAGNE

EXPERIENCE CLINIQUE AVEC LA SUSPENSION SH 617 (L) EN MYELOGRAPHIE

par

H DIETZ E ZEITLER et N FONTAINE

Dans la serie des substances de contraste positives employees en myelographie se placent des suspensions qui en raison de leur forme de solution et de leur capacite de resorption se situent entre les produits de contraste non resorbables (type Pantopaque Lipiodol) et ceux rapidement resorbables (type Methiodal Abrodil Contraste U) Sur ces entrefaites il serait convenable de considerer le SH 617 (L) comme la plus conforme des preparations de ce genre En voici la formule chimique



(β (3 Dimethylamino methylenamino-2, 4 6 trijodphenyl) propionsaure athylester)

Teneur en iode 61 45 % Solubilite insoluble dans l eau soluble dans l acide chlorhydrique l acetone l ether et l alcool ethylique Resorption complete en 6—12 semaines Injection sous-occipitale ou lombaire Anesthesie aucune

C'est une preparation de la firme Schering, Berlin, laquelle, apres avoir ete experimentee sur plus de 1 000 cas, s'est revelee posseder toutes les proprietes que doit avoir un produit de contraste positif utilise en myelographie, a savoir (1) bonne capacite de melange avec le liquide cephalorachidien, (2) totale capacite de resorption dans un temps de resorption plus long, (3) bonne compatibilite locale et generale, (4) bonnes images radiologiques, et (4) inutilite de l'anesthesie

Deja en 1961 ZEITLER a commence a mettre, cliniquement, le produit a l'epreuve, et dans les annees suivantes, pratique plusieurs experiences sur les animaux de laboratoire, accompagnees d'examen histologique En 1963, il presenta, pour la premiere fois, dans le congres de Strasbourg, les resultats de ses essais experimentaux et ses experiences cliniques avec 40 patients De meme, VOGLER & WALCHER (1963), BACIOCCO et coll (1966), et SCHAFER et coll (1965), ainsi que ZEITLER & DIETZ (1965) publierent leurs premiers resultats avec cette preparation

Materiel et Methode Nous avons, jusqu'ici, pratique a Mayence 316 myelographies avec le SH 617 (L) dont 18 cisternales et 298 lombaires En voici les techniques utilisees

1 Pour la myelographie lombaire le malade est place en decubitus lateral, le cote malade sur la table d'examen qui est inclinee a 15—20° du côté ou repose la tete du patient Dans cette position, la ponction lombaire est realisee au niveau de l'espace L2—L3 Une anesthesie spinale est superflue Un gramme du produit de contraste est suspendu dans 5 ml d'une solution de glucose a 5,5 % et cette derniere suspension, une fois de plus, melangee avec 5 ml de liquide cephalorachidien Apres l'enlevement du liquide lombaire, lequel avait servi au melange, on injecte au malade d'abord 50 mg de prednisolone (sous la forme de solu decortine H de la firme Merck), en guise de prophylaxie contre les reactions d'incompatibilite intrathecale, puis la suspension liquide glucose produit de contraste

Les cliches radiologiques sont tires en plusieurs plans par des rayons horizontaux, au moyen d'un Bucky Blende pour cassettes flexibles, place verticalement sur le cote de la table d'examen La suspension descend lentement, pendant 5 a 10 minutes, dependant de la gravitation, dans le sac lombaire recouvre sous l'aspect d'une legere couche de neige, les fibres du cauda et la surface interne de l'arachnoide et de l'enveloppe radiculaire On obtient, ainsi, une repartition relativement egale du produit de contraste et une representation des fibres du cauda equina, dependant de la position du corps (Fig 1)

Les gros processus expansifs se presentent sous la forme caracteristique d'arret total, ainsi se demontre, par exemple, une hernie discale mediale totale Les

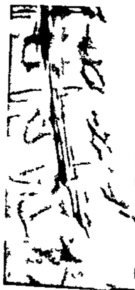


Fig 1



Fig 2a



Fig 2b

Fig 1 Representation normale de la region lombaire selon le diametre incline de l appareil 5 minutes apres injection d un gramme de SH 617 (L) dans l espace L2—L3 Les enveloppes et le parcours radiculaires du cote ou est couche le patient ainsi que les filaments isoles du cauda apparaissent tres bien

Fig 2 Hernie discale dorsolaterale droite L5—S1 Cliches tires au moyen d un tube place lateralement avec des rayons horizontaux cote droit du patient incline (a) position oblique (b) position droite 5 à 8 minutes apres injection d un gramme de SH 617 (L) dans l espace L2—L3

petites images la plupart hernie discale dorsolaterale (Fig 2) se laissent diagnostiquer a partir du deplacement des fibres colorees du cauda ou a partir du repoussement de la dure mere de la face posterieure du corps vertebral ou bien encore a partir des irregularites des filaments radiculaires se presentant par exemple comme une excavation une amputation des racines nerveuses ou des changements dans leurs angles de parcours Des details plus approfondis de radiodiagnostic sont decrits plus precisement dans une autre publication (ZEITLER & DIETZ 1965)

2 *Pour la myelographie cisternale* l injection du produit de contraste est faite de la meme façon que pour la lombaire apres l introduction de 50 mg de predni solone 1 g du produit de contraste suspendu dans le melange 10 ml de liquide lombaire glucose est injecte sans anesthesie intrathecale L inutilite de l anesthesie rend possible la demonstration aussi bien des segments cervicaux que dorsaux du canal vertebral L injection cisternale est realisee en position assise ou en de

Tableau 1

Avantages du SH 617 (L) comparés aux produits de contraste aqueux et huileux

I Avantage principal les caracteres de la suspension
  Bonne capacite de melange avec le liquide cephalorachidien
  Résorption lente mais complète
  Sedimentation lente
  Direction de la sedimentation influençable par les changements de position
  Fine buee du contraste sur toutes les surfaces des structures
II Avantages des techniques de la radiographie
  Examen possible independamment de la pression du temps
  Deux phases possibles dans la prise des cliches (1) pendant la sedimentation (2) apres la sédimentation (tomographie)
  Tomographie encore possible pendant le libre passage du produit (largeur du canal spinal demontrable)
III Avantages des techniques de l examen
  En comparaison (1) avec les produits de contraste aqueux inutilité de l anesthesie donc aucune possibilité de complications causees par l anesthesie libre mobilisation du patient aucune procedure de position du malade apres l examen injection lombaire et sous-occipitale possible injection lombaire aussi possible dans la position inclinee de la tête
  En comparaison (2) avec produits de contraste huileux pas de formation de gouttelles coloration fine homogène et bonne affinité avec les surfaces en presence pas de fuite pendant le libre passage du produit inutilite du retrait du produit
IV Avantages diagnostiques
  Pas de superposition conduisant à une epaisse couche du produit
  Meilleure reconnaissance des details

Tableau 2

Réactions secondaires causées par la myélographie avec le SH 617 (L)

Réactions immédiates
  Injection lombaire douleurs en ceintures et au dos meningisme
  Injection sous occipitale meningisme nausees vomissements vertiges bourdonnement d oreilles cephalees douleurs au dos
Reactions secondaires (3 a 4 jours post injectionnelles)
  Céphalées et douleurs au dos meningisme augmentation en intensite des complaintes radiculaires élévation de la temperature (de 1 a 2 C rectale) augmentation des cellules dans le liquide cephalorachidien (entre 20/3 et 10 000/3)
Reactions retardees
  Impotence sexuelle (4 cas)

cubitus incline du patient Elle ne doit pas être faite trop rapidement pour ne pas favoriser une descente brusque des cristaux dans le canal spinal

Ici encore, le relativement lent processus de sedimentation offre plusieurs avantages (1) on est echappe a la pression du temps durant l examen (2) la prise des cliches peut se realiser en deux phases (A) pendant le processus de



Fig 3 Tumeur intraspinale extradurale avec syndrome d'arrêt complet au niveau de D1—D2 a) Arrêt total du produit de contraste au niveau de C7—D1 à droite et C6—C7 à gauche 10 minutes après injection sous-occipitale d'un gramme de SH 617 (L) Les enveloppes et le parcours radiculaires sont bien reconnaissables de même que le tassement du produit de contraste sur la tumeur en projection au dessous de l'apophyse épineuse de C7 b) Dans la projection latérale l'arrêt de la tumeur est superposé à l'épaule c) La tomographie pratiquée après progression de la sédimentation du produit de contraste selon un diamètre incliné de la position ventrale droite à la position dorsale gauche montre distinctement la forme et l'état de la surface tumorale au dessus du capuchon du produit de contraste

sédimentation c'est à dire immédiatement après l'injection ou après un temps encore plus éloigné pourvu que la direction de la sédimentation puisse être encore influencée par les changements de position du malade ainsi on obtient la visualisation de structures déterminées par exemple les enveloppes radiculaires de la partie latérale ventrale ou dorsale de la moelle épinière et (B) après la fin de la sédimentation des clichés tomographiques peuvent être tirés

Fig 3 a et b montre les images d'une tumeur cervicale extradurale au niveau de C6—C7 pendant la sédimentation Sa dimension et sa direction d'expansion sont particulièrement bien mises en évidence dans la tomographie suivante (Fig 3c)

Enfin attirons l'attention une fois de plus sur les avantages de la complète résorption du produit de contraste le temps de résorption porte sur deux semaines à quelques mois. Fig 4 montre la diminution graduelle de la substance de contraste au cours d'un contrôle fait 2 et 4 mois après la myélographie Habituellement 2 à 3 mois après la myélographie le produit ne peut plus être démontré radiologiquement

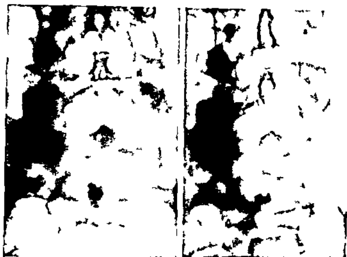


Fig. 4. Exemple de la résorption du SH 617 (L) dans la partie terminale caudale du sac dural. Examen de contrôle fait 2 mois (a) et 4 mois (b) après la myélographie.

A côté des avantages sus-dessus mentionnés du SH 617 (L), présentés encore une fois plus clairement dans le Tableau 1, dans leur relation avec les produits de contraste aqueux d'une part, et huileux, d'autre part, il existe aussi une série de désavantages sur lesquels l'on s'appuie un peu passionnément et d'une manière exagérée pour jeter sur le produit une certaine méfiance tout à fait imméritée. Comme, avec tous les autres produits de contraste positifs, jusqu'ici connus, on enregistre aussi avec le SH 617 (L) quelques effets secondaires qui ne sont ni si graves ni si courants pour porter à condamner le produit, comme, par exemple, l'avaient fait SHELDON (1965) ainsi que SCHAFER et coll. (1965).

Les effets secondaires que nous avons observés (Tableau 2) reposent, avant tout, sur les caractères de suspension du produit de contraste. Du fait que les cristaux du produit de contraste se déposent sur les tissus, ils les affectent particulièrement à leur surface active et provoquent ainsi des excitations méningéales et des irritations de la racine nerveuse. Les complaintes sont individuellement très différentes et s'observent le plus couramment avec l'examen cisternal. Nous différençons les réactions immédiates, apparaissant au cours de l'injection des réactions secondaires, lesquelles s'installent après l'examen. Parmi les complaintes subjectives, se placent celles qui apparaissent, au premier plan, en rapport avec une irritation des méninges et des racines nerveuses tandis que, comme réactions objectives, peuvent apparaître occasionnellement une hausse de la température (au soir de l'examen, ainsi qu'au premier jour après l'examen) et une augmentation des cellules dans le liquide céphalorachidien.

Ces apparitions peuvent être considérablement réduites par une injection in

trathécale préalable de 50 mg prednisolone, ce que nous pratiquons depuis 1964, et qui a aussi fait ses preuves d'une façon incroyable dans la RIHSA myélographie (DIETZ, ZEITLER & WOLF 1966). Ainsi les troubles subjectifs sont rejetés, tout à fait à l'arrière plan, apparaît encore mais assez rare, une élévation de la température, sous une forme légère et passagère. Une augmentation cellulaire dans le liquide céphalorachidien est aussi comme précédemment, observée après l'injection, comme réaction du produit de contraste. Elle était avant l'emploi de la prednisolone de 1 000/3 à 10 000/3 cellules dans les premiers jours post injectionnels. Par contre avec l'injection préalable de la prednisolone elle n'est seulement que de 20/3 à 2 000/3. Les patients deviennent alors le plus souvent libres de toutes complaintes.

Une prolifération cellulaire apparaît notoirement toujours comme réaction non spécifique sous une forme plus ou moins grave si des corps étrangers sont introduits dans l'espace liquidien. Elle ne doit pas être exploitée ou exagérée car elle disparaît comme les autres réactions tissulaires synchrones du leptoméninges (hyperhémie, stase, oedème, inflammation séreuse), après quelques jours (HEMPEL & ZEITLER 1965).

Toutes ces apparitions d'effets secondaires dépendent aussi manifestement de la dose: il ne doit pas être employé pendant l'examen plus de 1 à 2 g de substances de contraste correspondant à une quantité de 15 à 30 mg/kg de poids corporel. Personnellement nous avons seulement 6 fois, injecté 2 g, dans les autres cas seulement 1 g.

À cause de la possibilité d'apparition de troubles sexuels (lesquels se voient, pertinemment, avec tous les produits de contraste positifs) on ne doit poser l'indication de la myélographie que d'une manière très critique et très restreinte (DIETZ & ULBRICHT 1967).

En pesant tous les arguments parlant en faveur et contre le SH 617 (L), il reste à constater, eu égard aux bons résultats des expériences réalisées avec ce produit, que les avantages tant du point de vue technique que diagnostique, l'emportent de beaucoup sur les désavantages. De ce fait nous ne pouvons donc que recommander l'emploi du produit. Nous croyons de plus que sa forme de suspension est une forme idéale de produit de contraste pour la myélographie et que les recherches futures prendront cette direction.

RESUMÉ

Il est rapporté sur les expériences faites avec l'emploi du SH 617 (L) comme suspension myélographique chez 316 patients. La technique utilisée est brièvement décrite. Les avantages des caractères de la suspension comparés à ceux des préparations aqueuses et huileuses sont démontrés et les effets secondaires observés sont discutés.

SUMMARY

Experiences with SH 617 (L) used as a contrast suspension in myelography of 316 patients are reported and the technique is briefly described The advantages of this suspension in comparison with aqueous and oily preparations, as well as the secondary effects that may occur are discussed

ZUSAMMENFASSUNG

Erfahrungen mit Suspensionen von dem Kontrastmittel SH 617 (L) die fur Myelographie bei 316 Patienten angewendet wurden werden vorgelegt und es wird uber die Technik kurz berichtet Die Vorteile die mit solchen Suspensionen im Vergleich zu wassrigen und oligen Mitteln erreicht werden konnen sowie die Sekundareffekte werden diskutiert

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Editorial note

Primum non nocere. This ancient rule for the medical profession must continue to be a guiding principle in our work today, and not least in matters connected with diagnosis. With this in mind and in view of the recommendation to use SH 617 L as a contrast medium for myelography expressed in the preceding article, the editors of Acta Radiologica have considered it expedient to insert the following review, despite the fact that it was not presented at the Symposium. As will be seen, the views concerning this contrast medium are controversial.

EXPERIENCES WITH SH 617 L

by

ERIK LINDGREN and GUNNAR TORNELL

A report on a new contrast medium manufactured by Schering and intended for myelography was presented by ZEITLER at the Symposium on Neuroradiology, Strasbourg, in 1963. The medium was called SH 617 L and had been tested in 120 rabbits. With a dose of 40 mg/kg body weight, 95 % of the rabbits had no side effects, while a dose of 80 mg/kg body weight affected 50 % of the animals given this dose and two of them died within four weeks. Clinical trials had also been carried out in adults, with a dose of 1 000 mg (i.e. 5 ml). No side reactions occurred immediately after the injection or during the roentgen examination, but a few hours later and during the first few days after the examination many of the patients had a transient temperature rise and an increase of cells in the cerebrospinal fluid, comparable to that occurring after lumbar puncture alone or at myelography with the common, previously used contrast media. The side effects

From the Roentgen Department (Director: Prof. Erik Lindgren), Serafimerlasarettet, Stockholm, Sweden.

were thus not considered severe, and the preparation was recommended for clinical use.

The delegates at the Symposium must have gained the impression that the 'ideal contrast medium' for myelography had at last seen the light, especially since it was also stated to be ideal from the standpoint of the roentgen technique. This impression was to some extent strengthened by a paper published the same year by VOGLER & WALCHER, describing investigations in rabbits and dogs with a dose of 50 mg/kg body weight. No paralysis or paresis was observed but the rabbits had poor appetite ("Futterverweigerung") for two weeks afterwards and lost weight; five weeks later, however, they had regained their original weight. All the dogs had more or less severe signs of meningeal irritation but these had disappeared by the fourth day. One dog was killed after 20 hours and one on the fourth day. The cerebrospinal fluid contained increased protein and the cell content was raised. Spinal cord material was examined histologically but the results were not reported.

The paper also described the findings in 160 clinical myelographies at which 5 ml SH 617 L had been injected either through a lumbar or a cisternal puncture, without an anesthetic. After the myelography temporary meningeal irritation arose (not in all the patients), in the form of headache, slight meningism, pain in the lumbar region, a temperature of 38.5° C, moderately increased protein and an increased number of cells in the cerebrospinal fluid. Any radicular pain that had been present before was again temporarily activated. The symptoms were sometimes more severe than meningism following puncture and resembled those occurring after encephalography; they subsided after a few days and the authors therefore considered there was no need to fear late damage. More than half the amount of contrast medium injected was still present at 3 to 4 weeks but only traces remained at 6 to 8 weeks. Unfortunately, no details regarding the material were given and it is difficult to form an exact idea of the incidence of the various side effects.

The first definitely critical report came from SHELDON (1964), in a letter to the British Journal of Radiology describing a patient examined with 5 ml of the substance. Severe headache, stiff neck, backache, and a temperature rise to around 38.3° C occurred 4 hours after the injection. Lumbar puncture at 12 hours yielded turbid fluid with an increased protein and cell content (mainly polymorphs). The signs and symptoms were so alarming that SHELDON decided not to use the preparation again.

SCHAFER, SCHUSTER & WEBER (1965) also warned against the use of SH 617 L. They had tried it in 13 patients in doses of 600 to 2 000 mg and had observed the same meningeal irritation in all of them. Ten of the patients had severe symptoms, with headache, vomiting, nuchal rigidity, and a temperature

of 39 C the symptoms subsided very slowly One patient underwent an operation 12 days after the myelographic examination and the inner aspect of the meninges as well as the nerve roots were found to be coated with a film resembling icing sugar (*Zuckerguss*) *The nerve roots in the cauda equina* were edematous and completely filled the dural sac, blocking the passage of the cerebrospinal fluid the blood vessels were greatly dilated In view of the distressing symptoms in all the patients as well as the operative findings the trials with the preparation were not continued

BACIOCCO GALUZZO & SASSAROLI (1966) had a similar experience In one patient operated upon (among 18 myelographies), the contras medium was observed to be closely spread as a thin film on the surface of the spinal cord Further clinical observations were published by ZEITLER & DIETZ (1965), who stated that 50 mg prednisolone given before the contrast injection would reduce the side effects They further observed (1967) that 1 5 g of the contrast medium should not be exceeded in adults and that the discomfort is worse after cisternal puncture and may then even be accompanied by vomiting

The most positive opinion has been expressed by WIDON & SCHMERWITZ (1968) however A series of 246 myelographies with SH 617 L enabled them to say that a contrast medium approaching as closely as possible what today, in theory can be expected of an ideal medium for myelography has been found A temperature of 38 to 39° C seldom higher slight headache, and mild meningism 4 to 5 hours after the injections were recorded in 20 to 30 % of the patients The symptoms subsided within two or three days and the patients were subsequently symptom free Side effects were thus apparently not the rule and the symptoms were mostly mild

Histologic studies have been described by HEMPEL & ZEITLER (1965) and FISCHER (1965) The former examined the leptomeninx from 12 patients operated upon after myelography with SH 617 L In addition the histologic changes in the arachnoid pia, spinal cord and brain were studied in a series of 77 rabbits fifty two of which had been examined by myelography with SH 617 L, five with Lipiodol five with Abrodil and nine rabbits with Pantopaque Changes were evident both in the operation specimens and in the experimental investigation They were the same irrespective of whether Lipiodol Pantopaque or SH 617 L had been used but were commoner and more severe after the first two media The most common findings were hyperemia edema and round cell infiltration, all of which were considered reversible but chronic inflammatory reactions and fibrosis were also observed The fibrosis occurred in six of the 52 rabbits examined with SH 617 L in seven of the nine with Pantopaque and in three of the five rabbits with Lipiodol

FISCHER compared Pantopaque SH 617 L ethiodol emulsion Conray and

physiologic NaCl in 30 cats divided into three groups Uniform histologic evidence of acute and chronic meningeal irritation was observed after Pantopaque It was also stated that 'SH 617 L caused severe meningitis in four of six animals, indicating a significant toxic hazard in its clinical use One illustration indicates anterior horn cell degeneration following the employment of SH 617 L

O MALLEY (1965) injected SH 617 L in nine rabbits in a dose of 100 mg/kg body weight The medium was not associated with any immediate or delayed physical reactions but produced dramatic changes in the cerebrospinal fluid which did, however, resolve over an extended period Attempts to modify this response by steroid and antihistaminic administration were unsuccessful

Present investigation

A dose of 3 5 to 5 ml SH 617 L was injected into the subarachnoid space in 4 dogs weighing between 14 and 24 kg The contrast medium was mixed with an equal amount of cerebrospinal fluid and injected suboccipitally A small amount of the medium was also injected into the soft tissue at the back of the neck in two instances Three dogs were observed for 14, 16 and 21 days, respectively, and one for 2 months, they were then sacrificed

The day after the examination, which was performed under narcosis, all the dogs were apathetic and unwilling to eat or stand up, and they whined when the head was bent downwards Two days later they were less affected but still reacted when the head was bent forwards After about one week they were eating and moving about normally The two dogs given contrast medium in the neck muscles reacted slightly when the head was flexed but not the other two No neurologic or other signs were observed later Roentgen and histologic examination revealed contrast medium persisting in the subarachnoid space in all the dogs, including the animal observed for 2 months

Histologic examination (Nordenstam) Inflammatory reactions with considerable granulation and foreign body material was seen 2 weeks after the injection The changes in some regions encroached on both dura and spinal cord (Fig 1), which also presented evidence of edema and inflammatory cell infiltration There were also adhesions between the dura and medulla The dog killed after 3 weeks had considerable thickening of the soft membranes and increased collagen in the arachnoid mater (Fig 2) In the animal that lived for 2 months there was thick, irregularly sclerosed granulation tissue (Fig 3), and a few thin walled blood vessels contained not entirely fresh thrombi (Fig 4) The dogs given a small dose of the medium in the neck muscles had necrotic foci, in other words signs of marked tissue irritation

The results in these animals as well as the complications mentioned in the



Fig 1 The pinal medulla with membranes and nerve roots Inflammatory cell infiltration of the medulla enc oaching upon the medulla

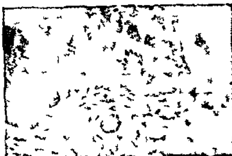


Fig 2 Uncommonly massive granulation in the soft membranes on the underside of the pons A few clumps of contrast medium surrounded by giant cells and epithelioid cells are present at the centre

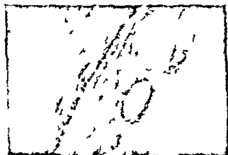


Fig 3 A thin layer of granulat on tissue partly detached from the du a lies on the inner a pect of the dura parts of this tissue a e scl rotic and the collagen is increased Lymphomonocytic cell inf ltration in the granul tion tissue



Fig 4 Three nerv roots and a thin walled blood vessel containing a not entirely fresh thrombus fairly *dense lymphomonocytic cell* infiltration near the blood vessel The stain ing p operty of the axons of the nerve roots is partly altered

literature have caused us to refrain from carrying out clinical trials with this preparation WICKBOM however before he knew about our investigation tried SH 617 L in three patients and has kindly allowed us to mention his observations A man aged 50 was examined for indefinite symptoms, mainly of the cervical rhizopathic type but slightly suggestive of syringomyelia and 5 ml SH 617 L were injected suboccipitally about an hour later the patient s pain became worse No definite side effects arose however The second case was one of a woman aged 40 with a long history of cervical rhizopathy About an hour after the suboccipital injection of 4 ml SH 617 L nausea dizziness and severe headache were experienced the following day she also had pain in the lumbar region radiating to the legs The symptoms gradually subsided over the next few days The side effects in this patient were considered severe In view of the mild symptoms in the first case however myelography with SH 617 L was performed in a third case a woman aged 24 with indefinite spinal pain A dose of 8 ml SH 617 L was injected suboccipitally and one hour afterwards she developed head ache which became rapidly worse as well as a temperature rise The patient had severe headache nausea and vomiting attacks and her general condition was affected over the next three days she then slowly improved Because of the alarming symptoms which in general accord with SHELDON s observations no further trials with the preparation were made

Conclusion

SH 617 L given to four dogs by subarachnoid injection in a dose of 0 2 ml/kg, i e 40 mg per kg had in every instance a toxic effect on both the membranes and the spinal cord ZEITLER reported that 95 % of a series of rabbits had no side effects from this dosage We have observed particles of contrast medium as late as two months after the injection Our results thus differ from those of ZEITLER and VOGLER & WALCHER but are in better agreement with those of FISCHER In view of the experimental results as well as the similar clinical observations described by several investigators the reports of some workers (particularly WIDOK & SCHMERWITZ) are difficult to understand provided the composition of the preparation was the same in the different studies Gas is in many respects more satisfactory as a contrast medium than positive media, it can give in formation that none of the positive contrast media at present available are capable of providing It is however less suitable for the investigation of root sleeves and for demonstrating angiomas A positive medium without irritative side effects would therefore be a valuable addition to our present collection of con trast media but unfortunately SH 617 L does not appear to fulfil that desider atum

SUMMARY

Experiences with the contrast medium SH 617 L in myelography are presented. Severe leptomeningeal reactions as well as parenchymatous degeneration have been observed.

ZUSAMMENFASSUNG

Es wird über Erfahrungen mit dem Kontrastmittel SH 617 L für Myelographie berichtet. Schwere Reaktionen in den Rückenmarkshäuten sowie parenchymatöse Degeneration wurden observiert.

RÉSUMÉ

Les auteurs présentent leurs expériences du moyen de contraste SH 617 L en myélographie. Des réactions leptoméningées graves ainsi que des dégénérescences parenchymateuses font déconseiller l'utilisation de ce moyen de contraste.

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ANGIOGRAPHIE DE LA MOELLE EPINIÈRE

par

R DJINDJIAN R HOUDART et M HURTH

L angiographie medullaire essentiellement utilisee jusqu a ce jour pour l identification et l approche therapeutique des anevrysmes arterio-veineux de la moelle voit ses indications s elargir parallelement a la progression des techniques neuro-radiologiques et a l exigence grandissante des neurochirurgiens

Depuis le premier cas d angiome cervical opacifie par arteriographie vertebrale rapporte par HENSON & CROFT en 1956 l interet de la methode s est, en ce qui concerne les malformations vasculaires nettement affirme au point d en faire actuellement l examen indispensable tant au diagnostic qu a la conduite du traitement chirurgical

Nous basant sur l experience acquise depuis 1962 (14) au contact des angiomes medullaires nous avons employe l arteriographie dans un certain nombre de processus pathologiques touchant la moelle compressions vertebro-discales tu meurs juxta medullaires accidents brutaux de nosologie imprecise et faisant evoquer la possibilite d un processus ischemique

Nous pouvons faire etat actuellement de 200 examens a visee medullaire et notre propos est de situer la valeur de l angiographie en fonction de ses difficultes techniques de ses risques, et de ses avantages specifiques par rapport aux autres procedes d investigation en pathologie vertebro-medullaire

SUMMARY

Experiences with the contrast medium SH 617 L in myelography are presented. Severe leptomeningeal reactions as well as parenchymatous degeneration have been observed.

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A *La moelle cervicale et la jonction cervico dorsale* sont irriguees par des branches issues, des deux cotes, du systeme sous-clavier

Pour la portion superieure sus-jacente au renflement cervical l apport arteriel est assure par les arteres vertebrales fournissant les deux arteres pinales anterieures et posterieures, et un rameau le plus souvent impair ne entre C3 et C5

Pour le renflement cervical, et la jonction cervico-dorsale la vascularisation provient du tronc cervico-intercostal (Fig 1b) sous forme d une artere impaire qui penetre en regle en C7 et gagne l axe spinal anterieur Deux autres arteres a destinee anterieure et a disposition symetrique viennent de l artere cervicale profonde au niveau de C5 ou C6 La participation de l arte e cervicale ascendante parait inexi tante ou negligeable

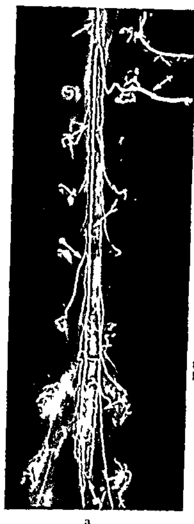
Sous l angle technique l *angiographie de la moelle cervicale* utilise les differentes methodes d opacification de l artere sous claviere et de ses branches les methodes globales telles l aortographie l arteriographie par voie humerale axillaire ou sous claviere peuvent etre completees par le catheterisme selectif par voie aortique de l artere vertebrale ou la ponction directe de cette artere

Chez le sujet normal seul l axe spinal anterieur dans sa partie haute peut etre opacifie par angiographie vertebrale encore cette injection n intervient elle que dans 50 % des cas (32) Ceci s explique par le tres fin calibre de ces arteres comme par l impossibilite technique d une injection selective

A l etat pathologique les modifications circulatoires locales (anevrysmes arterio-veineux ou ischemie) facilitent au contraire l opacification du reseau arteriel et autorisent un peu paradoxalement a parler d *angiogramme pathologique* alors que dans l etat actuel des techniques on ne peut decrire d angiogramme normal qu en se referant a l anatomie

B *La moelle dorso-lombaire et le cone terminal* sont alimentes par une artere volumineuse constante et unique dans 40 % des cas (Corbin) c est l artere d Adamkiewicz ou artere du renflement lombaire (Lazorthes) (Fig 1 a) Cette *artere nait le plus souvent a gauche entre D7 et L3* de l artere intercostale ou lombaire correspondante Elle represente l afference essentielle sinon exclusive du systeme spinal anterieur eventuellement *supplee par un pilier accessoire* grele sus-jacent ou beaucoup plus rarement par un rameau sous-jacent a son origine

L artere d Adamkiewicz donne inconstamment une branche po terieure destinee au reseau postero-lateral homolateral (21 27) A cote du systeme spinal anterieur on decrit en effet deux chaines anastomotiques verticales postero-laterales alimentees par des arteres posterieures multiples et asymetriques de calibre beaucoup plus fin que celui de l artere *du renflement* lombaire Les deux reseaux spinal anterieur et pinaux posterieurs sont anastomoses au niveau du cone



a



b

Fig 1 Preparations anatomiques a) Injection endo aortique de l ostium de l intercostale nourriciere de l artere d Adamkiewicz Dissection puis radiographie de la moelle Branche ascendante (←—) artere intercostale (←⊣) branche descendante (←⟷) artere perforante (←+) branche postero laterale (←∘) branche postero laterale (←⧺) corbeille terminale (←o) b) Injection selective de l axe spinal anterieur cervical a partir du tronc cervico intercostal opacification de l artère spinale antérieure Branche radiculo medullaire de l artère cervicale profonde (←—) tronc cervico intercostal (←⊣) branche radiculo medullaire de l artère intercostale (←⟷)

Bases anatomiques, technique, angiographie normale

Nos elements de reference anatomique sont tires des travaux classiques (1, 2 15, 34), contemporains (6, 18, 27 28, 29, 33) mais aussi de recherches personnelles (21, 26) reprenant par injections selectives sur cadavre, l etude morphologique analytique des principales afferences arterielles de la moelle (Fig 1)

La mise en evidence de l artere d ADAMKIEWICZ doit faire partie du bilan arteriographique aussi bien chez les sujets porteurs d anevrysmes arterioveineux dor o-lombaires, qu au cours de certaines compress ons medullaires vertebro-discales ou tumorales puisqu il s agit d un renseignement capital pour la conduite de l acte chirurgical Nous avons egalement pratique des angiographies a la recherche d une lesion vasculaire chez des patients atteints de paraplegies d origine indeterminee lors de ces examens, l opacification de l artere du renflement lombaire a toujours ete recherchee Ces faits expliquent que nous puissions parler d aspects angiographiques normaux Il est bien sur impossible de chiffrer nos echecs en ce domaine mais nous pensons que l aortographie selective permet d obtenir, dans un pourcentage de cas tres eleve l image directe des afferences arterielles normales de la moelle dorso lombaire (Fig 2)

C *Dans tous les cas,* qu il s agisse de vaisseaux normaux ou de constatations pathologiques la senographie est indispensable a l angiographie medullaire le logetron et la soustraction sont necessaire pour donner toute leur nettete a des images volontiers fugaces et constamment parasitees par les superpositions vasculaires et osseuses

Nous terminerons cette partie en signalant que sur nos 200 examens nous avons a deplorer un deces determine par un infarctus mesenterique chez une paraplegique agee de 69 ans seule ombre a une serie qui ne comporte aucun accident medullaire notable aucune aggravation de l etat neurologique anterieur

Nous devons cependant faire mention de six incidents survenus lors de l injection selective de l intercostale donnant naissance a l artere du renflement lombaire et consistant en secousses cloniques des membres inferieurs evoluant par salves de quelques econdes progressivement espacees et disparaissant en 2 a 3 minutes Le role du produit de contraste nous semble moins important a considerer dans la genese de cette epilepsie medullaire que l occlusion par l extremite de la sonde de l ostium de l artere intercostale privant ainsi la moelle de son apport sanguin principal Chez aucun de ces malades on n a enregistre d aggravation neurologique apres l examen Ces faits indiquent la necessite d un deroulement tres rapide des manipulations des la sonde en place prise immediate des cliches, puis retrait de la sonde apres rinçage au serum glucose xylocaine sans attendre le developpement des films

Applications pathologiques

A *Les malformations vasculaires de la moelle epiniere* Nous pouvons faire etat de 33 cas d angiomes medullaires angiographies Toutes nos observations concernent des anevrysmes arterio-veineux dont la structure est parfaitement



Fig. 2. Aortographie sélective. a) De la 11ème artère intercostale gauche : opacification de l'artère d'Adamkiewicz. Artère intercostale (←—) artère d'Adamkiewicz (←+). b) Profil. L'artère d'Adamkiewicz rectiligne plaquée contre le rebord postérieur du rachis en avant de la moelle. Artère d'Adamkiewicz (←—) artère intercostale (←+). c) Injection d'une artère postéro médiane para médiane issue de la 10ème artère intercostale droite. Artère intercostale (←+) artère spinale postéro-latérale (←∘).

médullaire par l'intermédiaire de la corbeille terminale ou arcade cruciale (Fig. 1a).

Sous l'angle technique, l'angiographie de la moelle dorso-lombaire est obtenue par aortographie selon la technique de Seldinger. Jusqu'en 1965 nous n'utilisions que l'aortographie globale, depuis cette date nos examens comportent le cathétérisme sélectif de chacun des orifices endo aortiques des artères intercostales ou lombaires dans la zone étudiée, et il s'agit donc d'artériographie sélective. L'angiographie globale conserve la valeur d'un examen d'orientation particulièrement utile en matière d'angiomes médullaires lorsque la localisation pré angiographique demeure imprécise. Partout ailleurs l'aortographie sélective d'emblée doit lui être préférée. La netteté des images ainsi obtenues permet une analyse beaucoup plus rigoureuse, tant sur les incidences de face, que sur les sériographies de profil, et l'innocuité de l'examen s'en trouve renforcée (nécessité d'une moindre quantité de produit de contraste, injection manuelle).

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Fig. 3. Angiome médullaire postérieur unipédiculaire irrigué par un pédicule postéro-latéral issu de la 12ème artère intercostale gauche. a) Aortographie. b) Soustraction. c) Aortographie sélective.

superposable à celle des angiomes cérébraux. L'absence de barrière capillaire et son corollaire l'existence d'un shunt artério-veineux sont admirablement analysés par l'angiographie qui fournit une image directe et vivante de ces lésions. Ce double intérêt nosologique et diagnostique largement détaillé dans nos publications antérieures (13, 22, 23), est entièrement confirmé par l'enrichissement de notre série comme par les données de la littérature (9, 35). Nous continuons donc à penser qu'au niveau de la moelle les seules malformations vasculaires rencontrées sont des anévrysmes artério-veineux et que le seul examen valable pour les étudier est l'angiographie. Cette notion ne met nullement en cause l'intérêt des autres explorations utilisables qui bien au contraire concourent à enrichir les indications et à préciser les modalités techniques de l'angiographie.

Les radiographies simples et tomographies du rachis nous ont permis de retrouver des anomalies dans 22 % des cas (images d'angiome vertébral dans 2 observations, scolioses dans 4 cas, élargissement du canal avec érosions corporéales ou pédiculaires dans 6 cas).

La myélographie à contraste positif est anormale dans 83 % des cas, et montre



Fig. 4. Angiome médullaire postérieur unipédiculaire (←—) irrigué par un pédicule postéro-latéral (←→) issu de la 11ème artère intercostale droite (←→). a) Aortographie. b) Profil. Pédicule postéro-latéral et masse angiomateuse sont loin du rachis derrière la moelle. c) Aortographie sélective de contrôle. Exérèse complète.

des images considérées comme caractéristiques dans 57 % des cas (empreintes vasculaires). Nous avons totalement renoncé à la phlébographie transépineuse, et ne possédons aucune expérience de la myélographie gazeuse, qui paraît cependant difficilement utilisable dans ce domaine où elle peut encore comporter le risque de déclencher une hémorragie. La myélographie à contraste positif dont il ne nous appartient pas ici de discuter les dangers et les inconvénients possède donc une bonne valeur d'orientation. Là s'arrêtent ses mérites et nous nous devons de signaler que dans un contexte évocateur il nous est arrivé à deux reprises de réaliser directement l'angiographie après contrôle radiologique simple du rachis et sans myélographie préalable.

La fidélité de l'angiographie en tant que moyen diagnostic est impossible à situer avec une rigueur absolue puisqu'en cas d'examen négatif l'abstention chirurgicale est le plus souvent la règle et que les vérifications anatomiques n'interviennent que tardivement dans l'évolution de cette maladie au long cours. Il importe cependant d'établir une distinction en ce qui concerne l'exploration de la moelle dorso-lombaire entre aortographie globale, et aortographie sélective. Chez sept de nos patients en effet l'aortographie globale s'est montrée négative ou insuffisamment explicite. Pour l'un de ces cas le diagnostic a été redressé par



a b c

Fig 3 Angiome medullaire postérieur uni pédiculaire irrigue par un pédicule postero lat ral issu de la 12ème artere intercostale gauche a) Aortographie b) Soustraction c) Aortographie selective

superposable celle des angiomes cerebraux L absence de barriere capillaire et son corollaire, l existence d un shunt arterio-veineux sont admirablement analyses par l angiographie que fournit une image directe et vivante de ces lesions Ce double interet nosologique et diagnostique largement detaille dans nos publications anterieures (13, 22 23), est entierement confirme par l enrichissement de notre serie comme par les donnees de la litterature (9, 35) Nous continuons donc a penser qu au niveau de la moelle les seules malformations vasculaires rencontrees sont des anevrysmes arterio veineux et que le seul examen valable pour les etudier est l angiographie Cette notion ne met nullement en cause l interet des autres explorations utilisables qui bien au contraire concourent a enrichir les indications et a preciser les modalites techniques de l angiographie

Les radiographies simples et tomographies du rachis nous ont permis de retrouver des anomalies dans 22 % des cas (images d angiome vertebral dans 2 observations, scolioses dans 4 cas, elargissement du canal avec erosions corporeales ou pediculaires dans 6 cas)

La myelographie a contraste positif est anormale dans 83 % des cas et montre

diagnostique de l'angiographie sélective sur l'aortographie *globale dont la négativité ne permet jamais d'éliminer* l'existence d'un angiome médullaire.

Nos IX cas d'aortographie globale négative concernaient tous des angiomes de petit volume de type fistule artério-veineuse simple alimentés par une artère afférente unique dont on conçoit aisément *qu'elle ait pu passer inaperçue en* l'absence de cathétérisme sélectif de l'intercostale ou de la lombaire qui lui donnait naissance. Sur le strict plan du diagnostic, l'angiographie médullaire et plus particulièrement l'angiographie sélective possèdent à notre avis une précision *inégalable et une très grande fidélité*. Les échecs de cette méthode parfaitement spécifique sont difficiles à chiffrer, mais paraissent en l'état actuel des techniques aussi rares qu'insurmontables.

Au delà du problème diagnostic l'intérêt capital de l'angiographie est d'avoir *permis un progrès considérable* dans le traitement chirurgical de la maladie (20, 24). Exceptionnelle, aveugle et dangereuse avant l'ère angiographique, l'exérèse totale de la malformation représente maintenant la technique de choix que nous avons utilisée pour *nos quinze derniers malades. C'est essentiellement* la pratique systématique de l'angiographie sélective qui a rendu possible ce progrès. Cette méthode d'investigation sélective n'est applicable qu'aux malformations sous jacentes à la jonction cervico-dorsale. En pratique, la grande majorité des cas *lui sont offerts puisque notre série ne comporte que* trois angiomes cervicaux pour dix localisations dorsales et vingt localisations plus basses situées. Cette répartition topographique conforme aux conclusions de WYBURN MASON que nous avons *prématurément critiquées sur la base d'une statistique limitée à 12* cas (13, 23) doit être considérée comme une donnée favorable aux explorations angiographiques.

L'intérêt de l'angiographie sélective en tant que bilan préopératoire est triple.

1. Elle fournit des divers constituants de la malformation une image d'une précision anatomique et permet d'identifier les différents pédicules artériels, leur *nombre, leur niveau de pénétration rachidienne*, la manière dont ils abordent la malformation, de situer la masse principale des shunt artério-veineux, de définir l'extension des efférences veineuses (Fig. 5) contrairement à l'aortographie globale *elle* est parfaitement adaptée à la mise en évidence des malformations de petit volume alimentées par un pédicule unique (*18 cas sur 33*) *dont l'imprégnation souvent* fugace bénéficie grandement de l'injection *directe* du produit de contraste au contact ou peu s'en faut de l'afférence nourricière (Fig. 3).

2. Elle permet la prise *systématique de clichés de profil* faciles à lire, incidence essentielle pour affirmer en toute sécurité le siège postérieur d'une *afférence*, le caractère rétromédullaire de l'angiome, tous renseignements indispensables à l'évaluation *des possibilités chirurgicales* (*Fig. 4*).

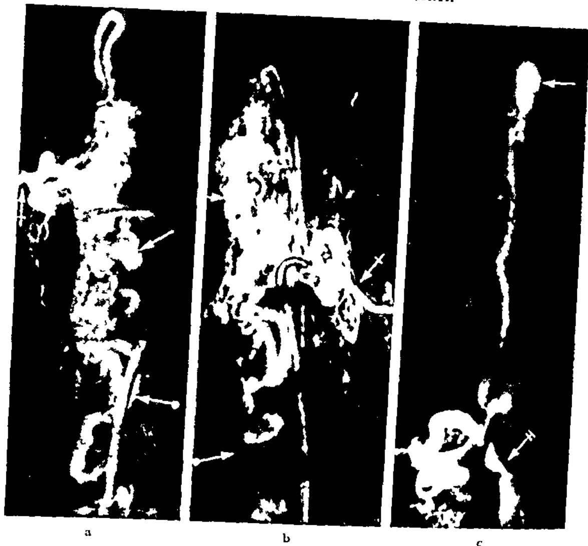


Fig 5 Angiome médullaire postérieur pluri pédiculaire irrigué par un pédicule postéro latéral a) D 11 droit 11ème artère intercostale droite (←+) masse angiomateuse (←—) veines de drainage (←o) b) D 12 gauche Masse angiomateuse (←—) 12ème artère intercostale gauche (←+) veines de drainage (←o) Un 3ème pédicule issu de la 2ème artère lombaire est mise en évidence en (c) Lac veineux angiomateux (←+) 2ème artère lombaire droite (←++)

l'intervention à une époque où nous ne faisions pas d'injections sélectives, pour les six autres par l'aortographie sélective Il est important de signaler que 5 fois sur 7, l'aortographie globale avait été pratiquée par des médecins possédant une excellente expérience de l'aortographie, mais mal familiarisés avec les exigences spécifiques de l'angiographie médullaire Ces faits soulignent à l'évidence la nécessité si particulière à la neuroradiologie, d'une étroite collaboration entre neurologues, radiologues, et chirurgiens Ils démontrent également la supériorité

distincte de l axe vasculaire principal l artere d ADAMKIEWICZ qu il importe de respecter Ce schema n est pas ideal mais correspond fort heureusement a la realite dans bon nombre de cas. Alors qu en 1965 (20) nous ne pouvions faire etat d aucun anevrysme arterio veineux medullaire traite par ablation chirurgicale, en deux ans nous avons pratique chez quinze malades l exerese de la malformation totale dans treize cas et subtotale dans deux autres. L angiographie selective a ete a la base de notre evolution therapeutique en nous donnant les precisions morphologiques qui nous paraissaient le prealable necessaire et suffisant pour aborder avec un minimum de risque le traitement radical des lesions C est encore l angiographie qui cautionne nos resultats sur le plan anatomique en permettant un controle post operatoire facile, rapide et anodin, qui confirme la disparition de la malformation (Fig 4c)

B *L ischemie medullaire* L obstruction totale ou partielle intrinseque ou extrinseque d un axe arteriel se traduit en regle par deux ordres de signes angiographiques quelque soit le territoire considere *signes directs* c est la desaxation arterielle sur l obstacle (saillie arthrosique ou vertebro-discale) ou l obstruction (tenose ou thrombose atheromateuse) *signes indirects* c est le developpement d un reseau de suppleance dont la connaissance prealable est capitale pour l interpretation des seriographies

Nous avons pratique un bilan angiographique chez sept malades porteurs de hernies discales dorsales ou de la charniere dorso lombaire (six cas) et chez un autre patient presentant une paraplegie sur cyphose Pottique A chaque fois l angiographie a permis d etablir un lien etroit entre l etage rachidien atteint et l artere d ADAMKIEWICZ soit que cette artere penetrat le rachis a l etage meme de la hernie discale soit que l une ou l autre de ses branches ascendante ou descendante a la face anterieure de la moelle soit directement deformee et refoulee par la lesion disco-vertebrale (Fig 7 Fig 8b) Dans une observation privilegiee la seriographie a montre l existence d un reseau de circulation collaterale en aval de la compression sous la forme d une vascularisation au niveau du cone terminal de la corbeille anastomotique qui ne s injecte jamais dans notre experience lorsque les conditions circulatoires sont normales (Fig 8a)

Sous un angle essentiellement pratique nous pensons que l angiographie apporte dans cette pathologie un renseignement capital sur le plan chirurgical en situant exactement l artere d ADAMKIEWICZ par rapport a la lesion Ainsi pourra t-on conduire l intervention en toute connaissance de cause non par laminectomie classique mais par une voie postero-laterale abordant le rachis du cote oppose a la penetration de l artere du renflement lombaire dont l atteinte est tres probablement la cle des complications chirurgicales comme des interpretations pathologiques D un point de vue plus theorique en effet il est difficile de retenir



a b

Fig. 6. Angiome pré- et intra-médullaire bi-pédiculaire irrigué par une artère radiculo-médullaire issue de la 9ème artère intercostale droite et la 10ème artère intercostale gauche. a) Masse angiomateuse de face (←—) pédicule antérieur intercostal D 9 droit dilaté (←+) axe artériel spinal antérieur normal (←+ı) pédicule antérieur intercostal dilaté D 10 gauche (←o). b) Le siège antérieur et intra de l'angiome et l'opacification de l'axe spinal antérieur. Masse angiomateuse de profil (←—) pédicule antérieur D 9 dilaté (←+) axe spinal antérieur (←+ı).

3. Elle autorise la recherche du niveau d'origine des afférences fonctionnelles de la moelle et plus particulièrement à ce niveau de l'artère d'ADAMKIEWICZ ou artère du renflement lombaire (LAZORTHES), dont il est important de connaître la situation par rapport à l'angiome et à ses pédicules, comme la non participation à l'irrigation de la malformation (Fig. 6).

Ainsi voit-on se dessiner dans toute sa netteté grâce à l'angiographie sélective, l'anévrysme artério-veineux schématiquement accessible à une cure chirurgicale radicale, malformation uni- (Fig. 4c) ou pauci-pédiculaire (Fig. 5 a et b) à maximum rétromédullaire comme ses afférences elles-mêmes (Fig. 4b) et

distincte de l'axe vasculaire principal l'artère d'ADAMKIEWICZ qu'il importe de respecter. Ce schéma n'est pas idéal, mais correspond fort heureusement à la réalité dans bon nombre de cas. Alors qu'en 1965 (20) nous ne pouvions faire état d'aucun anévrysme artério-veineux médullaire traité par ablation chirurgicale, en deux ans nous avons pratiqué chez quinze malades l'exérèse de la malformation totale dans treize cas et subtotale dans deux autres. L'angiographie sélective a été à la base de notre évolution thérapeutique en nous donnant les précisions morphologiques qui nous paraissaient le préalable nécessaire et suffisant pour aborder avec un minimum de risque le traitement radical des lésions. C'est encore l'angiographie qui cautionne nos résultats sur le plan anatomique en permettant un contrôle post-opératoire facile, rapide et anodin qui confirme la disparition de la malformation (Fig. 4c).

B. *L'ischémie médullaire*. L'obstruction totale ou partielle intrinsèque ou extrinsèque d'un axe artériel se traduit en règle par deux ordres de signes angiographiques quelque soit le territoire considéré : *signes directs* : c'est la désaxation artérielle sur l'obstacle (saillie arthrosique ou vertébro-discale) ou l'obstruction (sténose ou thrombose athéromateuse) ; *signes indirects* : c'est le développement d'un réseau de suppléance dont la connaissance préalable est capitale pour l'interprétation des sériographies.

Nous avons pratiqué un bilan angiographique chez sept malades porteurs de hernies discales dorsales ou de la charnière dorso-lombaire (six cas) et chez un autre patient présentant une paraplégie sur cyphose Pottique. A chaque fois l'angiographie a permis d'établir un lien étroit entre l'étage rachidien atteint et l'artère d'ADAMKIEWICZ, soit que cette artère pénétrât le rachis à l'étage même de la hernie discale, soit que l'une ou l'autre de ses branches ascendante ou descendante à la face antérieure de la moelle soit directement déformée et refoulée par la lésion disco-vertébrale (Fig. 7, Fig. 8b). Dans une observation privilégiée la sériographie a montré l'existence d'un réseau de circulation collatérale en aval de la compression sous la forme d'une vascularisation au niveau du cône terminal de la corbeille anastomotique qui ne s'injecte jamais dans notre expérience lorsque les conditions circulatoires sont normales (Fig. 8a).

Sous un angle essentiellement pratique, nous pensons que l'angiographie apporte dans cette pathologie un renseignement capital sur le plan chirurgical en situant exactement l'artère d'ADAMKIEWICZ par rapport à la lésion. Ainsi pourra-t-on conduire l'intervention en toute connaissance de cause non par laminectomie classique, mais par une voie postéro-latérale abordant le rachis du côté opposé à la pénétration de l'artère du renflement lombaire dont l'atteinte est très probablement la clé des complications chirurgicales comme des interprétations pathologiques. D'un point de vue plus théorique en effet, il est difficile de retenir



Fig. 7. Hernie discale D11—D12. Artère d'Adamkiewicz (←—) issue de la 10ème artère intercostale droite (←→). Encoche discale (←+).

comme coïncidence le voisinage qui réunit hernie discale et artère du renflement lombaire. L'angiographie apporte un argument positif de poids aux partisans d'un mécanisme vasculaire dans la genèse de ces médullopathies vertébro-discales (5, 7, 17, 21, 26). L'anomalie morphologique que constitue le refoulement de l'axe spinal antérieur par la saillie discale est certes insuffisante pour affirmer un défaut d'irrigation alors que la mise en évidence d'une circulation collatérale d'aval (Fig. 8a) donne à la réalité d'un déficit circulatoire une existence concrète impossible à négliger.

Dans la région cervicale, l'intervention d'un facteur vasculaire dans la genèse des atteintes médullaires de l'unco-discarthrose est souvent invoquée mais bien difficile à démontrer. L'angiographie ne permet pas l'injection sélective des afférences du réseau médullaire cervical qui normalement demeurent invisibles. Dans ce contexte, c'est leur injection qui doit être considérée comme pathologique. De fait nous avons obtenue à maintes reprises lors d'angiographies sous-clavières destinées à étudier le trajet de l'artère vertébrale au cou chez des sujets arthrosiques ou porteurs de malformations de la charnière cranio-cervicale l'apparition du réseau médullaire et de tout ou partie des artères du renflement cervical soit directement, soit sous l'effet de la rotation du cou dont on sait qu'elle réduit la circulation dans l'une des vertébrales. Nous pensons donc que l'injection



Fig 8 Même cas qu en fig 7 a) Opacification de la corbeille terminale de l artere d Adamkiewicz et de deux arteres radiculaire lombo-sacrées temoignant une circulation collatérale de suppléance Encoche discale (←+) artère d Adamkiewicz (←—) artere radiculaire lombo-sacree (—o) b) Profil Artere d Adamkiewicz soulevee par une volumineuse protrusion discale posterieure mediane Artère intercostale (←+) protrusion discale (←+) artere d Adamkiewicz (←—)

du reseau medullaire cervical peut etre le temoin d une insuffisance circulatoire dans le domaine des arteres vertebrales et prendre alors la signification d un systeme de suppleance en amont de l obstacle dont la valeur diagnostique n est pas nulle et merite d etre connue

On retrouve des faits entierement superposables aux precedents, lors des thromboses ou stenoses atheromateuse des arteres sous clavieres et vertebrales Les arteres radioculo-medullaires constituent une anastomose transversale entre



Fig. 7. Hernie discale D11—D12. Artère d'Adamkiewicz (←—) issue de la 10ème artère intercostale droite (←→). Encoche discale (←+).

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a b

Fig 9 Neurinome en sablier a) Opacification homogene d une volumineuse tumeur intra et extra rachidienne limitee par un cercle bordant irrigue par la 12eme artere intercostale droite (←→) soulevee Arret Lipiodol (←—) ligne bordant de la tumeur (←→) b) Profil Artere intercostale refoulee (←→) Lipiodol (←→)

possede donc la un premier interet celui d exclure une malformation vasculaire Son second interet est de donner une idee assez precise du volume de la moelle en delimitant les contours vasculaires (axes spinaux postero-lateraux et anterieur) dont l injection segmentaire suppose bien sur l angiographie selective qui contribue alors a affirmer et a localiser le processus expansif a l interieur de la moelle (Fig 10)

Enfin l angiographie permet probablement une approche etiologique nos deux ependymomes et notre unique astrocytome etaient avasculaires alors que l hemangiome nous a donne une image d injection qu il faut rapprocher de celles obtenues au niveau de l encephale

Huit fois il s agissait de tumeurs extradurales proches du trou de conjugaison mais developpees a travers lui en dehors du rachis Sept fois la tumeur etait un neurinome une fois un hemangiome epidural L angiographie apporte dans cette situation particuliere trois ordres de renseignements d inegale importance mais parfaitement specifiques

L existence meme d un processus expansif se trouve confirmee par l angiogra

les deux côtés et participent en cas d'obstruction segmentaire d'un des axes, à la revascularisation de *son territoire* au même titre, mais à un étage différent que le confluent anastomotique supérieur rétro-atloïdo-axoïdien (25, 28). Ces conditions très particulières expliquent probablement la fréquence relative avec laquelle on obtiendra dans ces cas l'injection des artères médullaires cervicales qui peut alors être interprétée comme le reflet indirect du trouble circulatoire.

Un dernier problème doit être évoqué à la fin de cette section consacrée aux *médullopathies* ischémiques, il s'agit de la possibilité de juger angiographiquement de la réalité d'une obstruction ou d'une sténose athéromateuse siégeant directement sur une afférence médullaire principale. Dans les conditions techniques actuelles, seule l'artère du renflement lombaire se trouve concernée ou plus exactement l'intercostale ou la lombaire en amont de sa naissance. Nous pensons avoir observé deux cas pour lesquels, en l'absence d'aucune autre étiologie décelable, une paraplégie d'allure vasculaire pouvait être rattachée à l'existence d'une sténose ostiale de l'artère intercostale donnant l'artère d'ADAMKIEWICZ, sténose démontrée par l'angiographie sélective. Ces faits sont à rapprocher des discussions soulevées par la mise en évidence, le rôle pathogène, et les possibilités thérapeutiques en matière de sténoses athéromateuses des artères mésentériques ou du tronc cœliaque. Sur le plan radiologique, on rencontre en effet les mêmes difficultés pour démontrer sans discussion possible l'authenticité de la sténose sur ces vaisseaux de fin calibre. Des recherches complémentaires sont nécessaires pour savoir si l'on doit accorder de la valeur à de pareilles images. C'est dire que l'opportunité d'un geste chirurgical demeure actuellement purement théorique.

C. *Les compressions tumorales de la moelle épinière.* L'utilisation de l'angiographie médullaire dans ce domaine habituellement réservé à la neuroradiologie classique des formations rachidiennes et intrarachidiennes qu'elle s'adresse aux investigations purement osseuses à la myélographie à contraste positif, ou à la myélographie gazeuse, est une des acquisitions récentes limitée certes mais très enrichissante de la méthode.

Nous pouvons nous référer ici à 22 observations pour lesquelles l'angiographie a représenté un moyen diagnostic et un guide chirurgical des plus importants. Les raisons pour lesquelles cet examen a été pratiqué sont variables en fonction de la localisation du processus tumoral. Les renseignements qu'il a fournis sont également variables en fonction de la topographie et de la nature des lésions.

Quatre fois il s'agissait de tumeur intramédullaires : deux épendymomes, un astrocytome, un hémangiome. Dans ces quatre cas les malades étaient des sujets jeunes, la séméiologie indiquait une lésion siégeant vraisemblablement dans la moelle, la myélographie laissait deux fois un doute sur l'existence d'empreintes vasculaires et la possibilité d'un angiome devait être éliminée. L'angiographie



a b

Fig 9 Neurinome en sablier a) Opacification homogene d une volumineuse tumeur intra et extra rachidienne limitee par un cercle bordant irrigue par la 12ème artere intercostale droite (←→) s ule ee Arrêt Lipiodol (←—) ligne bordant de la tumeur (←→) b) Profil Artere intercostale refoulee (←→) Lipiodol (←→)

possede donc la un premier interet celui d exclure une malformation vasculaire Son second interet est de donner une idee assez precise du volume de la moelle en delimitant les contours vasculaires (axes spinaux postero-lateraux et anterieur) dont l injection segmentaire suppose bien sur l angiographie selective qui *contribue* alors a affirmer et a localiser le processus expansif a l interieur de la moelle (Fig 10)

Enfin l angiographie permet probablement une approche *etiologique* nos deux ependymomes et notre unique astrocytome etaient avasculaires *alors que* l hemangiome nous a donne une image d injection qu il faut *rapprocher* de celles obtenues au niveau de l encephale

Huit fois il s agissait de tumeurs extradurales proches du trou de conjugaison mais developpees à travers lui en dehors du *rachis* Sept fois la tumeur etait un neurinome une fois un hemangiome epidural L angiographie apporte dans cette situation particuliere trois ordres de renseignements d inegale importance mais parfaitement specifiques

L existence meme d un processus expansif se trouve confirmee par l angiogra



Fig 10 Ependymome intra médullaire a) Écartement de deux artères postéro latérales issues de la 12eme artère intercostale gauche et de la 11eme artère intercostale droite témoignant d une augmentation de volume de la moelle Opacification d une veine retro medullaire dilatée et sinueuse Arrêt Lipiodol (←—) veine rétro médullaire dilatee (←+) *10ème artere intercostale droite* (←↔) *11eme artere intercostale* gauche (←↔) b) Profil Refoulement en arrière du paquet vasculaire postérieur Reseau postero latéral refoule en arriere (←∘)

phie du fait d une injection tumorale directe (sept fois), ou encore d une nette deformation des vaisseaux perirachidiens (Fig 9) L approche etiologique de viendra possible quand nous disposerons d un nombre de cas suffisants pour etablir des criteres d injection differentiels en fonction de la nature histologique

L angiographie permet en ce qui concerne les prolongements extrarachidiens un bilan d extension tres précis que n offrent pas les methodes habituelles et qui prend son importance pour la conduite de l acte chirurgical (Fig 9)

L angiographie selective donne le niveau d origine et de penetration rachidien nes des arteres medullaires, donc leur position par rapport a la tumeur, ceci est capital pour le chirurgien qui sans arriere pensee peut pousser tres largement son exerese lorsqu il sait a l avance que l artere du renflement lombaire par exemple

chemine a distance du secteur ou il va avoir a travailler Lorsque tumeur et artere d ADAMKIEWICZ siegent au meme endroit on conçoit l interet pathogenique les difficultes operatoires mais aussi l explication de certaines catastrophes chirurgicales

Dans sept observations le processus tumoral avait pour point de depart le rachis trois angiomes vertebraux une tumeur a myeloplaxe un chondrome, deux sarcomes La encore nous pensons qu une experience plus large de l arteriographie fournira un moyen supplementaire de prevoir en fonction des images, le type de tumeur en cause Ceci nous parait particulierement valable pour les angiomes vertebraux L injection directe des axes medullaires nourriciers de la moelle qu il s agisse des vertebrales dans le region cervicale ou de l artere du renflement lombaire pour la partie basse de la moelle revet comme pour les tumeurs du groupe precedent un interet chirurgical evident, en invitant l operateur a prendre toutes les precautions necessaires pour menager ces arteres hautement fonctionnelles

Dans trois cas enfin sequelles d osteoarthrite ou de spondylo-discite anciennes l angiographie dans un contexte etiologique imprecis en presence d images osseuses atypiques laissant un doute sur une pathogenie tumorale nous a apporte des arguments negatifs (absence d injection pathologique absence de proliferation extra osseuse) non negligeables pour le diagnostic

A notre avis l angiographie medullaire merite d etre consideree comme un examen precieux dont les indications en matiere de compression medullaire demandent a etre limitees en l etat actuel des choses a des cas murement selectionnes Il n est pas question de la mettre en concurrence avec les methodes classiques mais bien de la proposer comme exploration de complement dans un certain nombre de circonstances tres precises que sont l elimination d une malformation vasculaire l extension d une tumeur dilatant le trou de conjugaison la situation exacte d une tumeur pre ou latero-medullaire, d une neoformation a point de depart rachidien par rapport aux axes fonctionnels de la moelle

L avenir nous dira si l interet purement diagnostic de l angiographie merite *d etre retenu notamment en ce qui* concerne l approche etiologique des tumeurs comprimant la moelle

Conclusion

Nous pensons qu il est legitime d etablir un parallele entre angiographie cerebrale et angiographie medullaire Nouvelle venue l angiographie de la moelle aura comme son ainee a vaincre certains prejuges pour etre acceptee Des maintenant on peut affirmer qu elle represente la meilleure methode d exploration des malformations vasculaires spinales et qu elle apporte en matiere de compression

et d'ischemie medullaires des renseignements d'interet diagnostic et chirurgical qu'aucun autre examen *ne peut fournir* Si son innocuite doit a nouveau etre soulignee, ses indications demandent neanmoins a etre posees avec discernement Necessaire a chaque fois qu'un mecanisme vasculaire malformatif ou acquis est en cause, l'angiographie medullaire merite partout ailleurs discussion suivant l'argumentation que nous avons developpee et en fonction des services precis qu'elle peut rendre

RÉSUMÉ

Apres un bref rappel anatomique et technique et en se basant sur une série de 200 examens les auteurs discutent les indications et les resultats de l'angiographie de la moelle epiniere Les malformations vasculaires de la moelle sont la meilleure indication de cette methode Trente trois cas d'anevrysme arterio veineux ont ete examines la précision du diagnostic angiographique a permis une exerese radicale de la malformation dans quinze cas Les auteurs ont utilise l'angiographie medullaire dans vingt deux cas de tumeurs et sept cas de compression d'origine vertebro discale ils presentent enfin deux cas d'atherome et de stenose arterielle qui montrent l'interet de cette methode pour l'étude de l'ischemie de la moelle

SUMMARY

Angiography of the spinal cord and its indications are discussed on the *basis of 200* examinations and a brief survey of the anatomical and technical aspects is presented Vascular malformations are the major indications for employing the method Thirty three cases of arteriovenous aneurysms were examined and in fifteen cases the *diagnostic accuracy* permitted radical excision of the malformation Angiography of the spinal cord was used also in twenty two cases of tumour and in seven cases of compression of vertebrodiscal *origin The value of the method in investigations of the spinal cord in* ischemic disorders *is* illustrated by two cases of atheroma and arterial stenosis

ZUSAMMENFASSUNG

Angiographie des Ruckenmarkes und ihrer Indikationen werden auf Basis einer Serie von 200 Untersuchungen diskutiert und eine Übersicht der anatomischen und *technischen* Aspekte *wird gegeben* Verschiedene Gefassmissbildungen sind die wichtigsten Indikationen fur die Anwendung der Methode Drei und dreissig Falle von arteriovenosen Aneurysmen wurden untersucht und in funfzehn Fallen konnte eine radikale Excision *auf Grund der Genauigkeit* der Diagnose *durchgefuhrt* werden Angiographie des Ruckenmarkes wurde auch in zwei und zwanzig Fallen von Tumoren und in sieben Fallen von Kompression vertebrodiskalen Ursprunges angewendet Der Wert der Methode bei der Untersuchung ischamischer Sto rungen wird schliesslich mit zwei Fallen von Atherom und Arteriostenose illustriert

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FROM THE DEPARTMENT OF RADIOLOGY THE NEUROLOGIC CLINIC, CHARLES UNIVERSITY PRAGUE, CZECHOSLOVAKIA

PNEUMOGRAPHIC EXAMINATION OF LUMBAR DISC LESIONS

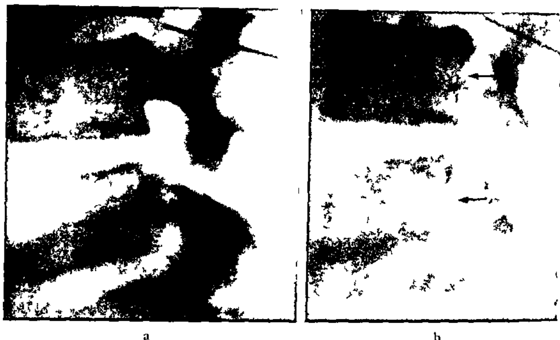
A new method

by

JAN JIROUT

The pneumographic examination of lumbar disc lesions is usually limited to the demonstration of indentations into the dural sac by the protruding extradural mass A dynamic feature was however introduced by REINHART & SCHOLZEL (1958) who produced an accentuation of the disc protrusion by retroflexion of the spine The present author has attempted to complement the examination by two different techniques This approach followed pneumographic studies of the mobility of the walls of the dural sac and of the variability in the width of the epidural space which disclosed that the relations between the anterior wall of the dural sac and the posterior aspect of the lower lumbar vertebrae change with alterations in intradural pressure

At least 40 ml of fluid are drawn off by the lumbar route with the patient recumbent By tilting the table 30 with the head lowered the intradural pressure in the caudal end of the dural sac decreases The decrease is followed by dorsal displacement of the anterior dural wall and widening of the anterior epidural space This becomes evident in lateral views when 20 ml of air have been introduced The further injection of about 60 ml of air results in an increase in



a b

Fig 1 a) Removal of 40 ml of fluid and injection of 20 ml of air increased the width of the anterior epidural space at the level of L4—L5 b) Narrowing of the epidural space is seen after increase of the intradural pressure with 50 ml more air

intradural pressure, displacement to the dural wall ventrally and narrowing of the anterior epidural space, at the same time the anterior contour of the air column is moulded by and assumes the curvature of the posterior concavity of the vertebral body (Fig 1)

This mobility of the anterior dural wall was studied in 266 cases in 81 of which abnormality of the thoracic or cervical spinal canal was clinically probable, the lumbar region was therefore regarded as being normal In 73 of these latter cases the dural wall was found to be mobile whereas only in 8 cases was there no reaction to the changes in intradural pressure In five of these cases an inadequate amount of fluid was drawn off and in one the dural sac ended abnormally high

The results seem to indicate that variations in the relation between the anterior dural wall and the posterior aspects of the vertebral bodies may be considered a normal response to changes in intradural pressure, i e a widening of the epidural space may thus occur in normal subjects It follows that a slight increase in the air pressure above the usually accepted upper limit is to be recommended

The dural wall is under tension in the initial stages of a disc protrusion even before it causes typical encroachment on the air column its normal reaction to

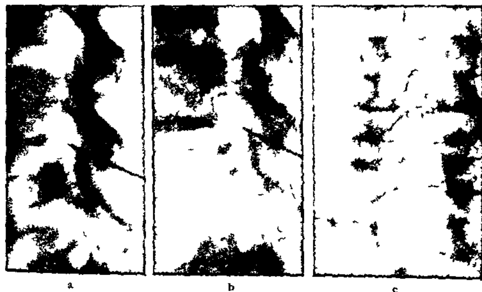


Fig 2 a) and b) Constantly increased width of the anterior epidural space at the level of L4—L5 unaffected by changes in intradural pressure indicates that the dural wall is under tension it is stretched by a disc herniation c) The a p view reveals the disc herniation

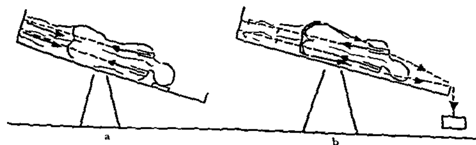


Fig 3 a) Active longitudinal compression of the spine b) Passive longitudinal compression of the spine

changes in intradural pressure is decreased or abolished (Fig 2) Widening of the epidural space resulting from the pressure of a disc protrusion may thus be differentiated from a normal anatomical variation

The degree of tension of the dural wall in cases with a disc herniation may also be evaluated A definite correlation between the degree of pneumographic pathologic findings and the mobility of the anterior dural wall was observed in 155 cases in 16 cases with pneumographic signs of massive disc prolapse no



Fig 1 a) Removal of 40 ml of fluid and injection of 20 ml of air increased the width of the anterior epidural space at the level of L4—L5 b) Narrowing of the epidural space is seen after increase of the intradural pressure with 50 ml more air

intradural pressure, displacement to the dural wall ventrally and narrowing of the anterior epidural space, at the same time the anterior contour of the air column is moulded by and assumes the curvature of the posterior concavity of the vertebral body (Fig 1)

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The dural wall is under tension in the initial stages of a disc protrusion even before it causes typical encroachment on the air column, its normal reaction to

The first variant that of active compression was applied in 118 cases The pathologic changes were distinctly accentuated in fifty four cases, uncertain in fifteen and unaltered in forty nine cases

The second variant that of passive compression was used in 121 cases with marked accentuation of the pathologic changes in sixty two cases, only slight abnormalities in twenty and unaltered conditions in thirty nine cases

Disc protrusion or its accentuation is usually evident in the lateral views Widening of the epidural space in the vicinity of the vertebral interspace resulting from longitudinal compression of the spine is considered an important sign and enables a differentiation to be made between normal and an abnormal dorsal bulging of the disc Similarly the appearance, or the reverse the disappearance, of the double contour sign are interesting features of the dynamics of disc protrusion in connection with longitudinal pressure on the spine

The presence or accentuation of lateral indentations resulting from an actual increase of the protrusion or from a widening of the dural sac, is evaluated in the a p projection (Fig 4)

The author considers passive compression of the spine more convenient for diagnostic purposes than active compression It allows pressure to be applied for a longer period it is not dependent on the patient s cooperation which may be precluded by pain Active compression, on the other hand produced atypical responses such as narrowing instead of widening of the epidural space in the lateral view or widening in place of narrowing of the dural sac in the a p projection Lateral indentations at the level of the L5 S1 in which a high degree of sacralization of L5 seemed to exclude any compression of the disc, also sometimes appeared These atypical reactions were considered to be due to contraction of the abdominal muscles to straining and holding of the breath resulting in alterations in the cerebrospinal fluid pressure and an increase in the filling of the epidural venous pathways

No attempt has been made in this paper further to analyse the pneumographic appearances and the responses produced nor to correlate them with the clinical findings However even at present the method appears to yield a closer and a more detailed insight into the mechanism and dynamics of disc lesions

SUMMARY

A new method of pneumographic examination of lumbar disc lesions performed in a material of 239 cases is presented This is based upon active and passive longitudinal compression of the spine The value of the procedure in the diagnosis of disc protrusions and in the differential diagnosis between a normal and an abnormal condition is discussed



Fig 4 a) Lateral disc herniation at the level of L4—L5 deformation of the dural sac b) Longitudinal compression of the spine causing accentuation of the signs

movements of the dural wall were evident while in the remaining 139 cases good mobility was present in one half of the cases and no movement took place in about one third of the cases It may be assumed that the mobility of the dural wall is preserved in small and laterally situated herniations, whereas it is abolished in larger median or paramedian masses

The second part of the technique is based on longitudinal compression of the spine It was considereded that the pneumographic appearances could be made clearer if pressure, acting on the longitudinal axis of the spine and imitating the weight of the upper part of the body were applied This can be carried out in two different ways

1 The patient is held head downwards on the tilted table by means of straps over the shoulders and presses the soles of the feet upwards against a support This active compression is maintained for about 10 to 15 seconds, then a p and lateral views are obtained before it is released (Fig 3a)

2 A 30 to 40 kg weight acting in a cranial direction is applied by means of straps adjusted around the tubera ischii, so that compression in the longitudinal axis of the spine is affected This is maintained for about 10 minutes, then a p and lateral films are obtained (Fig 3b)

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DISCOGRAPHIC ANATOMICAL CORRELATION OF DEVELOPMENTAL CHANGES WITH AGE IN THE INTERVERTEBRAL DISC

by

ST A KIEFFER E M STADLAN A MOHANDAS and H O PETERSON

Injection of contrast medium into the intervertebral disc followed by roentgenographic studies was introduced by LINDGREN (personal communication) in the early 1940 s and popularized as a clinical diagnostic procedure by LINDBLOM 1944 1948) in the late 1940 s Nevertheless, despite nearly a quarter century of clinical experience understanding of the anatomical basis of the discogram and of the developmental changes with age in the intervertebral disc is still incomplete

The present study was initiated in an attempt to correlate the appearance of the disc on discography with the actual anatomical findings using post mortem specimens

Methods and Material

Post mortem discography was performed in 106 individuals, ranging in age from one day to 75 years These patients died from a variety of causes none had

At th time of this work Stephen A Kieffer was a Scholar in Radiological Research of the James Picker Foundation

ZUSAMMENFASSUNG

Eine neue Methode der Luftmyelographie wurde an einem Material von 239 Fällen von lumbalem Diskusprolaps angewandt. Die Methode ist auf aktive oder passive longitudinale Kompression der Wirbelsäule basiert. Der Wert der Methode zur Abklärung des Diskprolapses und zur Differenzialdiagnose des Normalen und Abnormalen wird erörtert.

RÉSUMÉ

L'auteur décrit une nouvelle méthode d'examen pneumographique des lésions discales lombaires qui a été pratiquée dans 239 cas. Elle est basée sur la compression longitudinale active et passive de la colonne vertébrale. L'auteur examine l'intérêt de cette technique pour le diagnostic des protrusions discales et pour le diagnostic différentiel entre le disque normal et le disque pathologique.

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diffuse from the nucleus pulposus into the surrounding annulus fibrosus after a few minutes It was evident that a colloidal suspension similar to the red lead gelatin suspension originally used by LINDBLOM (1944) was needed A thin suspension of micronized barium sulphate proved satisfactory as it remained localized within the nucleus, enabling direct correlation with the roentgenogram In specimens from infants and young children up to the age of 5 years however, the high intranuclear pressure prevented injection of this colloidal suspension A weak solution of uranyl trinitrate proved satisfactory in these cases and also gave good visual correlation because of its yellow color

The volume of solution injected varied from 0 3 ml in the infant to 2 0 ml in subjects in the fourth and fifth decades Mean volume in the adults was about 1 5 ml The contrast medium was injected until considerable resistance was felt, the needle was then withdrawn and films in anteroposterior lateral and axial projections were exposed using the overhead tube (1 0 mm focal spot 40—60 kV 30—100 mAs and non screen film in cardboard cassette)

Both the injected and the uninjected discs were preserved in a 10 % formalin solution for 7 to 10 days. The specimens were then sectioned in sagittal and parasagittal planes Several discs in each age group were also sectioned in coronal and horizontal planes Representative discs from each age group were examined histologically

Discographic anatomical correlation

The intervertebral disc at birth consists of four distinct components (HADLEY 1964) two end plates of hyaline cartilage attached to the contiguous vertebral bodies a peripheral fibrocartilaginous ring (the annulus fibrosus) and a central gelatinous nucleus pulposus (Fig 1a) The nucleus pulposus is sharply demarcated from the annulus has a clear or grayish translucent appearance, and bulges on cut section reflecting the considerable intranuclear pressure (HENDRY 1958 NAYLOR 1958) The annulus is usually thicker anteriorly than posteriorly Microscopically *the nucleus contains groups of notochordal elements in a large* volume of faintly blue staining mucoid material The laminated fibers of the annulus blend superiorly and inferiorly with the cartilaginous plates (Fig 1b) The discogram correlates well with the gross appearance of the disc showing uniform contrast filling of an area corresponding in location to the nucleus pulposus Fig 2)

During the first decade of life with growth in height of the vertebral bodies the cartilaginous plates become thinner (Fig 3) Densities appear within the nucleus pulposus as early as 12 days of age chiefly located near its periphery this material is irregular in shape and distribution but occurs more frequently

Table

Developmental changes in the intervertebral disc seen in discograms of post mortem specimens

Age in years	Number of cases (total 106)	Single plate		Double plate				
		Smooth	Variations	No communication	Site of communication			
					Posterior	Anterior	Lateral+	Central
0—9	33	33	0	0	0	0	0	0
10—19	14	0	13*	0	1	0	0	0
20—29	15	0	4*	1	7	2	2	0
30—39	13	0	2**	2	8	0	1	0
40—49	11	0	0	0	6	4	3	1
50—59	10	0	3***	0	5	1	0	1
60—79	10	0	5***	1	1	1	0	2

* In these seventeen discs a notch was noted usually on the anterior aspect of the contrast outlined nucleus

** In these two discs filling with contrast medium was noted in only one plate However on gross section another gel like area was noted which had not been contrast filled most likely these discs belong in the group labelled no communication and the area not filled would have been demonstrated if a second puncture had been attempted

*** In these eight discs the contrast medium was irregularly distributed in linear configurations this may conform to the development of fissures and crevices

+ In all discs having a lateral communication this was continuous with a posterior communication therefore these discs are listed in both columns

known disease of the intervertebral discs The age distribution by decades is fairly uniform, except for the first decade of life where a greater number of discs were obtained (see Table)

En bloc removal of a segment of the lumbar spine including the L3—4 intervertebral disc and either the L2—3 or L4—5 disc, or both, was performed at the time of the general autopsy examination This was accomplished by sawing across the pedicles on each side, to avoid damage to the discs and adjacent vertebral end plates

Sections including the intact disc and a thin layer of vertebral body on each side were prepared, at least two such preparations were available from each subject One of these was injected, usually under fluoroscopic control, in a manner similar to clinical discography A long 23 or 25 gauge needle was introduced into the disc usually from its posterior aspect and advanced until no resistance was felt

Initially, sodium diatrizoate 50 %, mixed with patent blue dye, was employed as contrast medium However, early trials revealed that this medium tended to



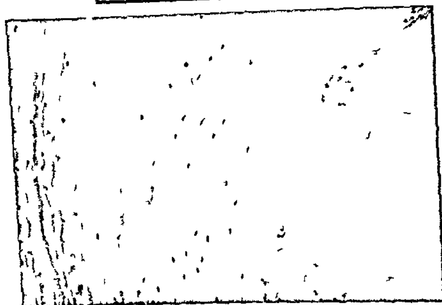


Fig 1 Intervertebral d sc and port ons of contiguous vertebral bodies in sagittal section taken post mortem f om a 1 -day old infant are seen in the upper color photograph Grayish trans l cent end plates of hyaline cart lage are seen adjacent to the vertebral bodies and between th cart laginous end plates a peripheral whitish fibrocartilaginous ring (annulus fibrosus) is seen which s sharply demarcated from the central gelatinous nucleus pulposus. In this illustra tio t the fa ntly gray decreased translucency of the nucleus is accentuated The annulus is thicker anteriorly (to the left on the image) and its fibers blend superiorly and inferiorly with the cartilaginous plates The low power photomicrograph of the margin between the nucleus (on the right) and the annulus (on the left) shows that the nucl us contains groups of physaliferous cells in a large volume of faintly blue staining muco d amorphous matrix the lamellae of the annulus are tightly packed

near the anterior margin of the nucleus With hematoxylin and eosin stain, the material has a slightly darker blue color and an amorphous or sometimes fibrillar appearance In general, the number and size of these deposits increase during the first decade of life Correspondingly, the discogram demonstrates a progressive contraction of the diameters of the deposits of contrast medium, the diameter of the nucleus relative to that of the entire disc gradually diminishes

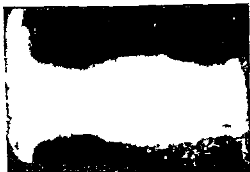
Early in the second decade, the configuration of the contrast filled nucleus on the discogram begins to change (Fig 4) A notch appears, usually on the anterior aspect of the nucleus, less commonly, this concavity occurs on the posterior or lateral margins of the nucleus There is a tendency towards clumping of the dense material mainly at the periphery of the nucleus, these dense deposits merge almost imperceptibly with the annulus fibrosus The previously tightly packed lamellae of the annulus are less closely arranged, and the annulus appears wider Whereas in the first few years of life the lamellae of the annulus fibrosus are all oriented convex outward, the more deeply situated lamellae now bulge inward towards the nucleus This inward folding of the lamellae of the annulus and the adjacent clumping of dense nuclear material correspond to the location of the notch on the discogram

In the latter part of the second decade, the discogram shows further deepening of the anterior filling defect Sections of the disc display further invagination of the deeper lamellae of the annulus and of the progressively more dense tissue of the nucleus, findings which correlate with the deepening notch in the discogram

By the third decade, the discogram usually presents the image of two parallel plate like collections of contrast medium communicating posteriorly, this is the classical adult discogram, showing features which persist for many years (Fig 5) The same appearance is met with in the great majority of individuals between ages 20 and 60, less commonly, the communication may be anterior, lateral, or central, in order of decreasing frequency Rarely, no communication is demonstrated on discography The separation into two plates represents a further stage in the gradual accumulation of dense material in the mucoid nucleus which assumes the appearance of fibrocartilage like that of the annulus The two areas of the nucleus that fill with contrast medium are relatively more gel like and less dense than the intervening tissue

By the fifth decade, the fibrocartilage shows breaks in its lamellar character and crevices appear (ECKERT & DECKER 1947) If such a crevice crosses sufficient lamellae to reach the outer aspect of the disc herniation of nuclear material may occur (Fig 6) This was noted in 3 of 10 injected discs in the fifth decade, in 4 of 10 discs in the sixth decade and in 4 of 10 discs in individuals in the seventh and eighth decades



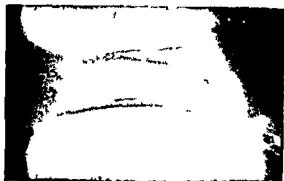


F g 4 Discogram and injected disc from an 11 year old child There is a notch on the anterior aspect of the nucleus which corresponds in location to the changes observed in the stained specimen The lamellae of the annulus are less closely arranged than earlier in life and the more d eply situated lamellae bulge inward towards the nucleus. Dense material on the anterior aspect of the nucleus tends to merge with the annulus The cartilaginous end plates are very thin.





Fig 5 Discogram and injected disc of specimen from a 27 year old subject A thin solution of micronized barium sulphate has been injected into the nucleus The d nse material in the nucleus has assumed the appearance of fibrocartilage like that of the annulus. The areas of the nucleus filled w th contrast medium are relati ely mo e gel like in the uninjected specimen than the intervening non filled tissue



a



b

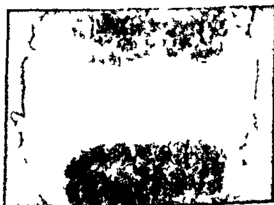
Fig. 2 a) Discogram from a 3 week old infant. The contrast medium corresponding to the nucleus pulposus is uniformly distributed; posteriorly it has leaked through the needle tract and out under the posterior longitudinal ligament. b) Injected disc from a 9 month old infant. The nucleus has a yellowish caste due to the uranyl trinitrate contrast medium.







a



b

Fig. 3 *Discograms in lateral, a.p. and axial projection and injected disc of specimen from a 2 year old child.* Intranuclear dense material, irregular in shape and distribution, is present near the anterior margin; the cartilaginous end plates are thin.



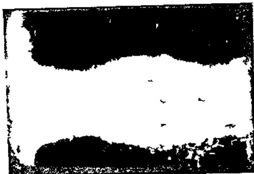


Fig 4 Discogram and injected disc from an 11 year old child There is a notch on the anterior aspect of the nucleus which corresponds in location to the changes observed in the stained specimen. The lamellae of the annulus are less closely arranged than earlier in life and the more deeply situated lamellae bulge inward towards the nucleus. Dense material on the anterior aspect of the nucleus tends to merge with the annulus The cartilaginous end plates are very thin



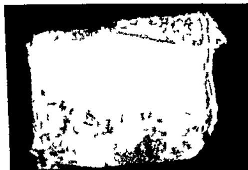


Fig 5 Discogram and injected disc of specimen from a 27 year old subject A thin solution of micronized barium sulphate has been injected into the nucleus The dense material in the nucleus has assumed the appearance of fibrocartilage like that of the annulus The areas of the nucleus filled with contrast medium are relatively more gel like in the uninjected specimen than the intervening non filled tissue





Fig 6 Discogram and horizontal section of disc from a 57 year old subject The discogram is a composite one of lateral anteroposterior and axial projections showing leakage of contrast medium through a fissure and under the longitudinal ligaments There is a crevice in the posterolateral portion of the annulus on the left The less dense nuclear material (brownish color) points toward this fissure





Fig 7 Discogram and injected disc of specimen from a 58 year old subject Contrast medium demonstrates communication between the superior and inferior plates anteriorly this is a less common location

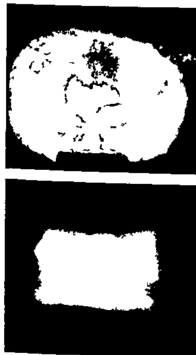




Fig 8 Discograms in axial (top) and lateral (lower) projections and color photographs of contrast filled and uninjected discs from a 70 year old subject The contrast medium may lie in a linear fissure or group of fissures practically no mucoid substance remains in the nucleus



Fig 9 Specimen from a 38 year old subject Dense material fills the center of the nucleus with residual mucoid matrix lying in plates superiorly and inferiorly Two separate needle punctures were required to fill these plates

With advancing age as the nucleus becomes more dense, gross differentiation between nucleus and annulus becomes more difficult However sufficient less dense nuclear material may remain to cause a normal bilocular discographic appearance even into the seventh decade (Fig 7) The oldest subject to demonstrate this normal appearance in this series was 63 years of age

Beyond age 63 in this series there virtually remained no mucoid substance, and the discogram presented irregularly linear configurations, which may conform to the development of fissures and crevices (Fig 8)

Discussion

The gross and histologic changes in the intervertebral disc with age have been described by COVENTRY, GHORMLEY & KERNOHAN (1945) and by ECKERT & DECKER (1947) There has been no attempt in this paper to record again in detail the anatomical changes in discs A study dealing with the developmental ageing and degenerative changes in the disc is in preparation (MOHANDAS et coll)

The typical configuration of the lumbar discogram in the adult is that of two parallel plate like collections of contrast material communicating posteriorly This differs markedly from the infant and young child in whom only a single collection of contrast medium is seen The anatomical basis for the infant discogram is readily apparent from gross examination of the injected disc contrast medium fills the entire mucoid nucleus pulposus This was first observed several years ago by one of us (H O P) in injected discs from autopsy specimens

The specific alterations within the disc upon which the changes in the discographic image appear to be based are probably due to two processes (1) an alteration in the clear mucoid matrix of the nucleus pulposus, and (2) an invagination into the nucleus of the more deeply located lamellae of the annulus fibrosus

The earliest change in the nucleus is the appearance of cloudy amorphous material apparently representing a physico-chemical alteration in the matrix This was seen in all specimens from individuals 2 years of age and older and was encountered in small amounts in some specimens from subjects even in the first few weeks of life COVENTRY GHORMLEY & KERNOHAN (1945), in their very detailed descriptions of the changes in discs with age commented upon this alteration which however was first seen in their series in specimens from the second decade of life However only five subjects under 10 years of age were included in their series These amorphous densities become more prominent with increasing age and are found more commonly in the anterior portion of the nucleus and to a lesser extent elsewhere near its periphery

The *second change*, invagination of the more deeply situated lamellae of the anterior portion of the annulus, was first encountered early in the second decade of life This bulge occurred at the same time as a notch was first noted on the discogram By the third decade of life, this invagination was sufficiently deep to establish the adult bilocular discographic image The encroachment of the invaginating annulus into the gel like nucleus, and the accumulation of progressively more dense material within the nucleus, limit the distribution of the contrast medium to the *superior, inferior, and posterior* portions of the nucleus The resulting discograms show two parallel plate like collections communicating posteriorly (28 cases)

Occasionally, the invagination proceeds from the posterior aspect and the residual communication is then *anterior*, this was seen in 8 of the 46 discs with a bilocular discographic configuration (see Table) The invagination is rarely asymmetric, thus leaving a lateral communication continuous with the posterior one, this was found in 6 cases More rarely, the invagination may occur on both the anterior and the posterior aspects resulting in a central communication (4 cases) or no communication (4 cases) This latter appearance was not recognized on discography until two separate punctures had been made (Fig 9)

BUTT has suggested (1963) that the contrast medium does not diffuse through the nucleus pulposus but rather coats the outside of the nucleus, lying in a recess between it and the surrounding annulus This study demonstrates the contrast medium within the area occupied by the mucoid portion of the nucleus pulposus in individuals up to the sixth or seventh decade of life

Presumably, no subjects selected for this study had a history suggestive of disease in the intervertebral disc Nevertheless, there was a relatively high incidence of rupture of the annulus fibrosus in subjects above the age of 40 (11 of 31) These observations correlate well with the clinical impression that rupture with leakage of contrast medium out of the nuclear compartment and under the longitudinal ligaments occurs frequently without signs and symptoms of nerve root compression

SUMMARY

Post mortem discography was performed in 106 subjects aged 0—75 years who had no history of intervertebral disc disease Anatomical observations were correlated with the discograms in each case The transition from a unilocular discographic image in the infant to a bilocular image in the adult appears to be due to two factors (1) accumulation of dense material within the mucoid matrix of the nucleus pulposus resulting in a gradual diminution in the mucoid matrix and (2) invagination of the most deeply placed lamellae of the annulus fibrosus into the mucoid nucleus Thirty five per cent of the injected discs in subjects above 40 years of age had rupture of the annulus despite lack of clinical evidence of nerve root compression

ZUSAMMENFASSUNG

Eine post mortale Discographie wurde bei 106 Personen im Alter von 0 bis 75 Jahren durchgeführt bei denen keine intervertebralen Erkrankungen in der Anamnese vorlagen In jedem einzelnen Fall wurden die anatomischen Befunde zu denen des Discogramms in Relation gestellt Der Übergang von einem uniloculären discographischen Bild beim Kinde zu einem biloculären Bild beim Erwachsenen scheint auf zwei Faktoren zu beruhen 1 der Ansammlung von dichterem Material innerhalb der mukoiden Matrix des Nucleus pulposus welche zu einer zunehmenden Verminderung der mukoiden Matrix führt und 2 der Invagination der am tiefst gelegenen Lamellen des Annulus fibrosus in den mukoiden Nucleus 35 Prozent der injizierten Zwischenwirbelscheiben von Personen über 40 Jahren wiesen Rupturen des Annulus auf obwohl keine klinischen Zeichen einer Nerv Wurzel Kompression vorlagen

RÉSUMÉ

Les auteurs ont fait des discographies post mortem sur 106 sujets agés de 0 à 75 ans qui n avaient pas d antecedent d affection des disques intervertebraux. Dans chaque cas ils ont confronte les constatations anatomiques avec les discographies Le passage d une image discographique uniloculaire chez le nourrisson a une image biloculaire chez l adulte parait due a deux facteurs (1) l accumulation de materiel dense dans la matrice mucoide du nucleus pulposus aboutissant a une diminution graduelle de la matrice mucoide et (2) l invagination des lamelles les plus profondes de l annulus fibrosus dans le nucleus mucoide Trente cinq pour cent des disques injectes au dessus de l age de 40 ans presentaient des ruptures de l annulus fibrosus malgré l absence de tous signes cliniques de compression radiculaire

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THE VERTEBRAL GROOVE

by

M ROTH

The vertebral groove is a characteristic feature in man and does not exist in quadrupeds (Fig 1) The formation of the groove is closely linked with straightening of the originally strongly curved embryonal body (Fig 2) The groove appears gradually as is clearly seen in cross-sections of an early human embryo (Fig 3) It can be reproduced experimentally by means of an elastic axis bearing a rib like structure (Fig 4a), with straightening of the axis (Fig 4b), the para axial parts of the 'rib ring' are displaced dorso-medially, the displacement increasing with the degree of straightening Since the caudal part of the thoracic spine is more involved than the cranial part in the process of straightening (Fig 2) the groove gradually deepens caudad

This arrangement of the groove is reflected in shifting of the costo transverse joint facets from a strictly vertical orientation cranially to an oblique one caudally (Fig 5) The caudal ribs during the process of groove formation are displaced on to the cranio-ventral surface of the transverse processes (cf Fig 2)

The embryonal thoracic spinal nerves attached to the thoracic wall are thus exposed to two traction components (ROTH 1966), one derived from the ascent of the cord and directed craniad and the other from the groove formation, directed dorsad The shape of the intervertebral foramina depends on the pre

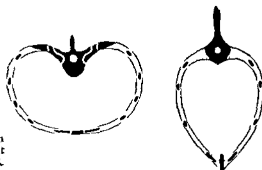


Fig 1 The vertebral groove exists in man (left sketch) but not in quadrupeds (right sketch) (Redrawn from BENNINGHOFF & GOERTLER 1960)

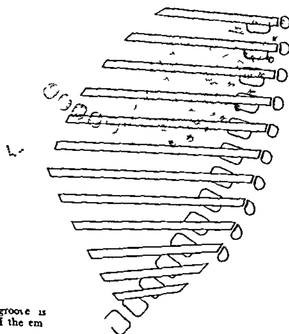


Fig 2 The formation of the groove is closely linked with straightening of the embryonal body (dotted)

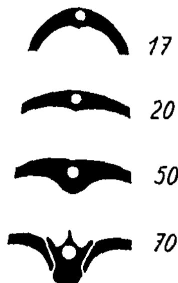


Fig 3 The gradual appearance of the groove can be studied in cross sections of early human embryos the figures represent lengths of the fetuses in millimeters (According to BARDEEN 1905)

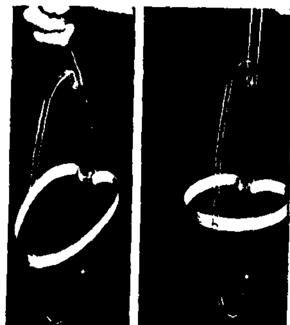


Fig 4 Experimental reproduction of the groove in plastic material With straightening of an elastic axis bearing a rib like ring (a) a paraxial groove gradually appears (b)

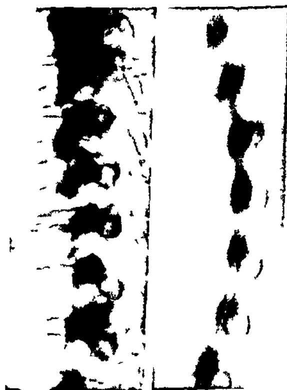


Fig 5 The costo transverse joints in oblique (about 15) projections conventional film (left) and tomogram (right)



Fig 6 Modelling of the embryonal foramen by traction of the spinal nerve illustrated in plastic material (a) pear shaped thoracic foramen (b) and kidney shaped lumbar foramen (c)

valence of the former or the latter component, as demonstrated in a foramen cut in plastic material (Fig 6) The embryonal foramen, originally circular, in the thoracic region gradually becomes pear shaped In the lower thoracic region with the dorsad traction component prevailing the foramen extends more dorsad whereas in the cranial thoracic region, where the ascent component prevails the orientation of the foramen is somewhat vertical (Fig 7a) The lumbar nerves in man as well as the thoracic nerves in quadrupeds lack the dorsad traction component the thoracic foramina in the dog (Fig 8) consequently closely resemble the lumbar foramina in man (Fig 7b)

The present material suggests the dependence of skeletal shaping on the nervous structures during the developmental stage The spinal nerves appear earlier than the vertebral column so that they represent the form giving factor in the later stages of development when they become embedded in bone as though in lava (TONDURY 1958) Cartilage and bone have to adapt themselves to the shape of the nervous structures and not the opposite This is in full accordance with HOLTZER s (1952) experimental observations By maintaining a suitable distance from the neural tissue the pre cartilage cells are deployed in such a manner that a lumen whose size is a function of the enclosed nerve bundle will be formed in the cartilage It is suggested that a metabolic product is released by the nerve fibres to which chondroblasts react in a negative chemotaxic fashion

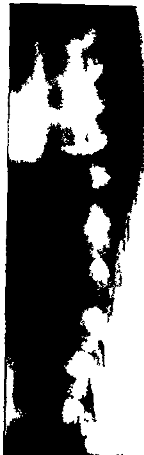


Fig 7a



Fig 7b



Fig 8

Fig 7 Tomograms of the intervertebral foramina in a child (a) and in the adult (b)

Fig 8 Tomogram of dog The thoracic intervertebral foramina resemble the lumbar foramina in man

SUMMARY

The development of the vertebral groove is explained and its influence via the spinal nerves on the shape of the intervertebral foramina is described

ZUSAMMENFASSUNG

Die Entwicklung der Wirbelsaulenrinne wird erlautert und deren Einfluss via die Spinal nerven auf die Gestaltung der Foramina intervertebralia wird beschrieben

RÉSUMÉ

L'auteur explique le developpement de la gouttière vertebrale chez l homme et décrit son influence par l intermédiaire des nerfs rachidiens sur la forme des trous de conjugaison

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MODELS OF VERTEBRO-NEURAL RELATIONS

by

M ROTH

The investigation of vertebro-neural relations in the cadaver is a difficult and time consuming procedure We have therefore attempted to reproduce some of the basic vertebro-neural phenomena described previously (ROTH 1966 1967) by means of models of both elastic and rigid types In spite of many shortcomings, this approach appears to be useful for a better understanding of some of the normal as well as the pathologic conditions of the spine

The *elastic model* allows a dynamical reproduction of the physiologic dispro portion in the vertebro neural growth A 'vertebral body fabricated of plexiglas (Fig 1) carries dorsally a key-ring representing the vertebral foramen and later ally two processes indicating the general orientation of the ribs and spinal nerves, the latter are made of rubber thread and are held on hooks along the ribs, pe ripherally they are attached to the rib and centrally to the spinal cord, which is composed of a textile material A short tube lies in the middle of the vertebral body and through it runs a rubber cord to indicate the longitudinal axis of the vertebral column The cervical and lumbar nerves are led along plexiglas rods orientated lateroventrally

The vertebrae are connected by three rubber strips inserted into the key rings Fig 2a represents the early embryonal stage with the spinal nerves still running mostly horizontally By pulling on the lower end of the model (Fig 2b) the

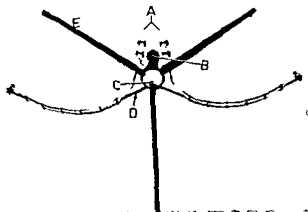


Fig 1 A thoracic segment in the elastic model viewed from above and slightly behind A — vertebral body B — longitudinal axis of spine C — spinal cord D — spinal nerve E — rubber strip

process of ascent usually conceived as an upward movement of the cord within the spinal canal is reproduced The conception of the ascent as a fixed cord within the spinal canal moving i e growing, distad in accordance with the biologic law of cranio-caudal development appears however to be more correct and practical (BUNAK 1961 HUXLEY 1932, KINGSBURY 1924 LIPPERT 1963 SCAMMON 1942) (Fig 3a) At the end of the second embryonal month the head is relatively enormous and forms about half of the body the spinal cord occupies the entire length of the spinal canal However the distal parts soon begin to grow rapidly the head becomes relatively small and the midpoint of the body is displaced distad (Fig 3b) The nerve structures with their rapidly declining growth rate cannot keep pace with this accelerated distal elongation of the body and the ascent of the cord is induced

This physiologic disproportion in osteoneural growth originates in the two diametrally different types of general growth that occur in vertebrates (ROTH 1967a) Whereas bone and most other tissues grow by cellular division and multiplication the spinal cord and nerves — as the only structures in the body — grow by mere elongation of the cells This is called extensive growth which is generally encountered in the vegetable kingdom This type of growth is governed in plants by the phytohormone auxin a derivative of tryptophan which is highly susceptible to a number of growth inhibitors both natural and artificial (AUDUS 1959 BONNER & GALSTON 1958, GUTTENBERG 1965 NEMEC & PASTYRIK 1963)

The formation of a nerve fibre is comparable to the outgrowth of a seedling

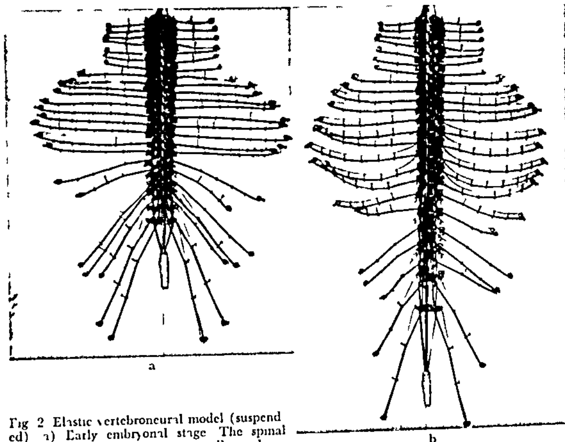


Fig 2 Elastic vertebroneural model (suspended) a) Early embryonal stage The spinal (excepting the lumbar) nerves still run horizontally b) Traction on the lower end of the model reproduces the ascent of the cord the distances between ribs and the intraspinal elongation of the lumbar nerves increase (cf fig 3)

(WEISS 1939) The nerve fibre is a process of the nerve cell, viz a bag with a membranous wall drawn out into an extremely long cylinder, this has led to a tendency to regard it more as a wire than a soft tube (YOUNG 1947) From the viewpoint of general biology the similarity between plant and nerve growth is striking, apart from the ability to react on external stimuli, such as light and touch, or to emanations common to both these seemingly so different structural elements

Vertebro-neural growth relations may be observed to better advantage in an isolated 'vertebra' (Fig 4) The spinal nerves attached to the inelastic spinal cord become longer when the model is stretched, i e they undergo extensive growth Absolute bilateral symmetry of this process is indispensable for the growing spine to maintain its straight course If, for example, the growth of the nerves becomes asymmetric by being retarded on one side, the spine will also be unilaterally affected, and scoliosis will develop (Fig 5)

The *rigid model* represents vertebro neural conditions in the adult (Fig 6, left

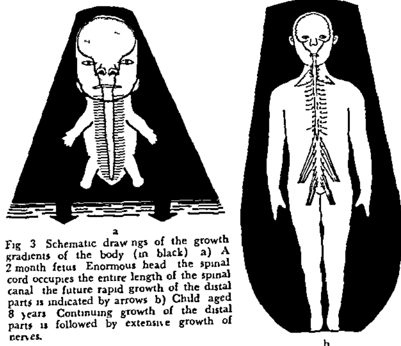


Fig 3 Schematic drawings of the growth gradients of the body (in black) a) A 2 month fetus Enormous head the spinal cord occupies the entire length of the spinal canal the future rapid growth of the distal parts is indicated by arrows b) Child aged 8 years Continuing growth of the distal parts is followed by extensive growth of nerves.

view) The vertebrae were made of plexiglas plates (Fig 6, top right and bottom right) attached to an axis permitting lateral flexion The average values of basic parameters, such as the dimensions of spine and ribs the angles of the rib axes and the lengths of the spinal cord segments were used in the construction Special care was taken in correctly shaping the intervertebral foramina (ROTH 1966) The spinal cord and nerves were made of a textile material and soaked in contrast medium

In a lateral roentgenogram of the model (Fig 7c) the same arrangement of the spinal cord is demonstrated as may be observed in gas myelography i e the cord runs along the dorsal wall of the spinal canal and its caudal end is curved ventrad The spinal cord in idiopathic scoliosis lies invariably in close contact with the concave sided wall of the spinal canal generally believed to be simply a consequence of the spinal curvature With the model in lateroflexion however (Fig 7b) the spinal cord maintains its median position within the spinal canal, and does not move towards the concavity of the curvature The same may be observed with the cord exposed in the cadaver

Some mechanism other than simple curving of the spine must therefore be responsible for the characteristic position of the spinal cord in idiopathic scoliosis,

Fig 4 Thoracic segment of the model suspended on three rubber strips a) Detailed view from behind The horizontal course of the spinal nerves corresponds to an early embryonal stage b) With the growth distad of the vertebral column (i e with traction on the lower end of the model) the spinal cord lags behind and the spinal nerves become symmetrically elongated (extensive growth) and angulated around the pedicles c) Same as (b) from in front d) Same as (b) and (c) from the side A — spinal cord B — spinal nerve C — rubber strips

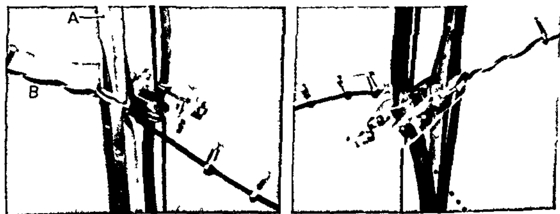


Fig 5 Extensive growth of the left nerve reduced by surrounding it with a white inelastic thread (B) (*cf* also fig 4b) The views are from behind (left) and from in front (right) The growth in length of the left side of the vertebra is reduced (wedging) and right convex scoliosis ensues (The dotted line indicates the course of the spinal axis with several vertebro neural segments *involved*) The vertebral body rotates towards the convexity and the spinal cord is displaced towards the concavity of the scoliotic curve (see Roth 1967) A — spinal cord B — inelastic thread

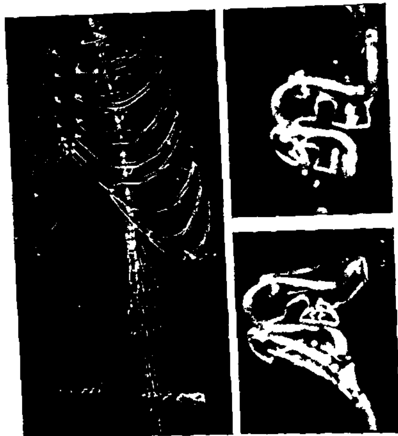


Fig 6 Rigid vertebroneural model in a general view (left) and representing the intervertebral foramina T1 (top right) and T8 (bottom right)

viz extensive growth insufficiency of the cord, an exaggeration of the physiologic vertebroneural growth disproportion The cord becomes too short for the vertebral column and the latter is gradually forced into curvatures (ROTH 1967) so that the shortened cord runs the shortest way within the curved spinal canal i e along the concavities This may be illustrated by a simple experiment with a metallic spring to represent the spinal canal containing a spinal cord (Fig 8) With scoliotic deformation brought about by the application of an extrinsic force the spinal cord remains roughly median (Fig 8a) Curving of the spring may also be accomplished however by pulling on the lower end of the cord i e by its relative shortening in relation to the spring The cord then maintains the shortest course along the concave sided wall (Fig 8b)

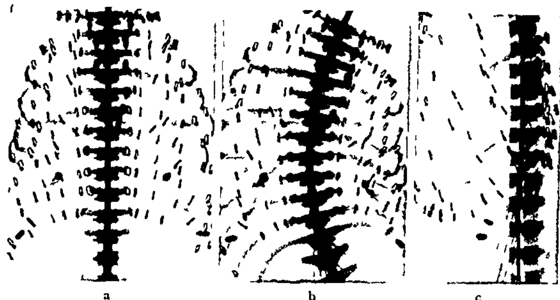


Fig 7 Roentgenograms of the model in a p projection (a) in a p projection with latero flexion (b) and in lateral projection (c)

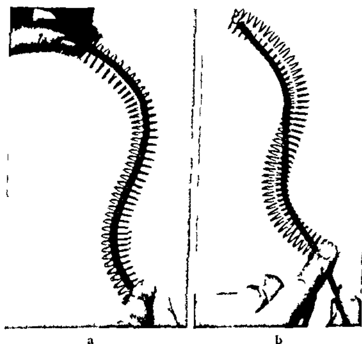


Fig 8 Metallic spring representing the spinal canal containing a spinal cord of textile material The scoliotic deformation of the spring has been brought about by an *extrinsic force* in (a) and by traction on the cord in (b)

SUMMARY

The basic principles of vertebro-neural growth relations with special reference to the pathogenesis of idiopathic scoliosis are discussed Plexiglas models constructed to assist in the demonstration, are described

ZUSAMMENFASSUNG

Die Grundprinzipien der Entwicklung der Wirbelsaule und des Ruckenmarkes werden in Bezug auf die Pathogenese der idiopathischen Skoliose erortert Es wurden Perspexmodelle angefertigt um die Entwicklung zu demonstrieren

RÉSUMÉ

L auteur examine les principes fondamentaux qui regissent les rapports vertebro neuraux au cours de la croissance ayant particulierement en vue la pathogenie de la scoliose idiopathique Il decrit les modeles en plexiglas qui ont ete construits pour appuyer sa demonstration

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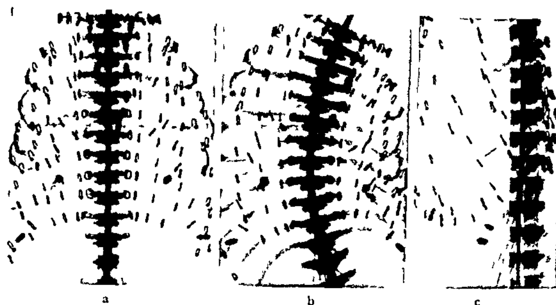


Fig 7 Roentgenograms of the model in a p projection (a) in a p projection with latero flexion (b) and in lateral projection (c)

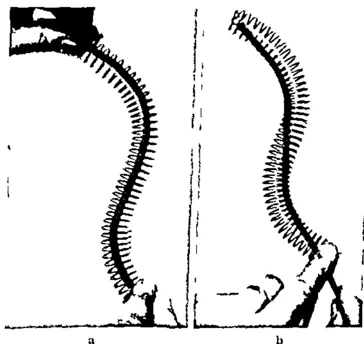


Fig 8 Metallic spring representing the spinal canal containing a pinal cord of textile material The scoliotic deformation of the spring has been brought about by an extrinsic force in (a) and by traction on the cord in (b)

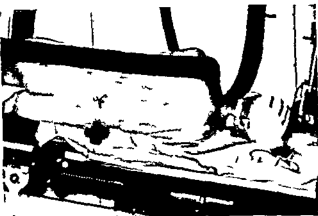


Fig 1 Le malade en Trendelenburg latéral Une aiguille est introduite dans les espaces sous-arachnoïdiens lombaires. Une autre est dans la partie extracrânienne de la grande citerne elle est reliée à une seringue de 100 ml qui recueille le liquide céphalo-rachidien et repose sur un coussin chauffant qui empêche le refroidissement du liquide

en position de Trendelenburg à 25° A ce moment la ponction sous-occipitale est réalisée avec une aiguille à deux robinets (comme celle utilisée pour l'encéphalographie fractionnée) Une des extrémités de l'aiguille est reliée à une grosse seringue de 100 ml par un tube de polythène Il s'agit d'un tube coupé dans une trousse de transfusion livrée en paquet stérile Il n'est pas réutilisé La seringue repose sur un coussin chauffant qui empêche le refroidissement du liquide Le système seringue tube n'est jamais déconnecté de l'aiguille à partir du moment où la ponction sous-occipitale est réalisée

L'injection d'air se fait par l'autre sortie de l'aiguille tandis que le robinet assurant l'issue du liquide céphalorachidien est fermé

Au moment où la mousse apparaît l'issue du liquide céphalorachidien vers la seringue est définitivement fermée Les quelques centimètres cubes de liquide céphalorachidien restant sont recueillis dans un autre récipient et destinés aux analyses habituelles

L'injection d'air est poursuivie jusqu'à concurrence d'une pression égale à 30 cm d'eau Le contrôle de la pression a été fait avec un manomètre de Claude

Ensuite l'examen radiologique se déroule normalement tandis que les deux aiguilles sont laissées en place (Fig 1) En s'assurant de la bonne position de l'aiguille sous-occipitale l'étude des répercussions des mouvements de flexion et d'extension de la tête sur la moelle cervicale peut être réalisée (Fig 2)

Après l'examen le liquide céphalo-rachidien est réinjecté lentement dans les espaces sous-arachnoïdiens sous-occipitaux tandis qu'un aide recueille simultanément dans une seringue l'air au niveau lombaire Quand du liquide céphalorachidien s'écoule par voie lombaire la réinjection par voie sous-occipitale est arrêtée

Généralement et suivant le niveau où la ponction lombaire a été faite, la

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MYÉLOGRAPHIE GAZEUSE SÉLECTIVE TOTALE

Une amélioration technique

par

ANDRÉ THIBAUT

Beaucoup de techniques ont été décrites pour réaliser la myélographie avec l'air comme moyen de contraste. Quand l'étude de la moelle elle-même est le but de l'examen, nous estimons que la technique sélective totale mise au point par LINDGREN et son école est la plus satisfaisante. Elle a deux avantages principaux. La définition des contours de la moelle est précise. La manipulation du patient est quasi nulle lorsque l'on dispose d'un appareillage radiologique adéquat.

Cependant, cette technique a un inconvénient. Après l'examen, le malade doit être maintenu en position de Trendelenburg pendant au moins quarante-huit heures pour éviter le passage dans la tête des 100 ou 125 ml d'air injecté et maintenu sous pression dans le canal rachidien.

Dans le but de supprimer cet inconvénient, nous avons, dans une série ininterrompue de 29 malades, réinjecté le liquide céphalo-rachidien aussitôt après l'examen radiologique et, simultanément, nous avons retiré l'air injecté.

Le procédé a déjà été appliqué en 1947 par VERBIEST (1950) au cours de la ventriculographie gazeuse directe dans les hydrocéphalies importantes par sténose de l'aqueduc de Sylvius.

Description de la méthode. Le malade est en décubitus latéral. La table est en position horizontale. A ce moment une aiguille est introduite dans les espaces sous-arachnoïdiens lombaires et est laissée en place. Ensuite la table est basculée

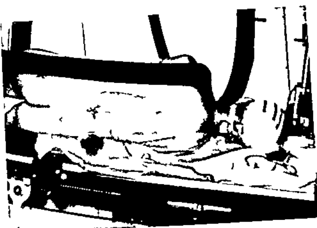


Fig. 1. Le malade en Trendelenburg latéral. Une aiguille est introduite dans les espaces sous-arachnoïdiens lombaires. Une autre est dans la partie extracrânienne de la grande citerne, elle est reliée à une seringue de 100 ml qui recueille le liquide céphalo-rachidien et repose sur un coussin chauffant qui empêche le refroidissement du liquide.

en position de Trendelenburg à 25°. A ce moment la ponction sous-occipitale est réalisée avec une aiguille à deux robinets (comme celle utilisée pour l'encéphalographie fractionnée). Une des extrémités de l'aiguille est reliée à une grosse seringue de 100 ml par un tube de polythène. Il s'agit d'un tube coupé dans une trousse de transfusion livrée en paquet stérile. Il n'est pas réutilisé. La seringue repose sur un coussin chauffant qui empêche le refroidissement du liquide. Le système seringue tube n'est jamais déconnecté de l'aiguille à partir du moment où la ponction sous-occipitale est réalisée.

L'injection d'air se fait par l'autre sortie de l'aiguille tandis que le robinet assurant l'issue du liquide céphalorachidien est fermé.

Au moment où la mousse apparaît, l'issue du liquide céphalorachidien vers la seringue est définitivement fermée. Les quelques centimètres cubes de liquide céphalorachidien restant sont recueillis dans un autre récipient et destinés aux analyses habituelles.

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Fig 2 Cliché de la moelle cervicale lors de l'extension de la tête Quand la position de l'aiguille sous-occipitale est correcte l'étude radiologique n'est pas gênée

quantité de gaz retirée est inférieure de 10 à 15 ml à la quantité injectée A ce moment, un contrôle radiographique est exécuté pour s'assurer de l'évacuation du gaz (Fig 3)

Résultats

Nous avons utilisé cette méthode consécutivement chez 29 malades

Pendant la réinjection du liquide céphalo-rachidien nous avons noté chez quatre *patients un besoin impérieux de miction* Aucun *phénomène n'a été observé* chez les vingt cinq autres

Aussitôt après l'injection, tous les malades ont été allongés en position horizontale Quelques-uns ont présenté une légère céphalée

Dans les jours qui ont suivi, vingt sept malades n'ont présenté aucune réaction anormale

Accidents Deux malades ont présenté une méningite dans les suites Dans les deux cas, la myélographie était normale

Dans le premier cas, il s'agissait d'une femme de 25 ans qui avait développé brusquement, huit jours après un accouchement normal, une quadriparésie avec troubles de la sensibilité à tous les modes ayant débuté dans la région périnéale



Fig 3 Controle de l'evacuation de l'air à la fin de l'examen Cliches du segment dorso-lombaire (a) et lombo-sacre (b) du canal rachidien avant le retrait (c) de l'air et apres (d)

L'affection s'etait compliquee brusquement de troubles respiratoires apres une phase de recuperation passagere Un traitement par cortisone avec une large couverture d'antibiotiques avait ete institue Avant l'examen l'analyse du liquide cephalo-rachidien avait montre 60 cg/l d'albumine avec 40 lymphocytes et 20 hematies mm³ Une meningite a pneumocoque est apparue vingt quatre heures apres l'examen Elle a gueri

Dans le deuxieme cas il s'agissait d'un homme de 55 ans atteint depuis vingt ans d'une myelopathie cervicale Une laminectomie bilaterale depuis C1 jusqu'a C7 avait ete realisee un an plus tot Au moment de l'examen, il presentait une quadriplegie flasque incomplete avec troubles des sphincters et retention urinaire Le liquide cephalo-rachidien etait normal Une meningite a bacille pyocianique est apparue cinq jours apres l'examen L'evolution a ete mortelle mais le traitement a ete contrarie

A la suite de ces accidents infectieux nous avons repris les 800 derniers

examens où nous avions injecté de l'air dans les espaces sous arachnoïdiens pour réaliser soit une myélographie soit une encéphalographie fractionnée. Sur ces 800 cas, 11 accidents d'allure infectieuse ont été observés. Dans 5 cas, aucun germe n'a été mis en évidence dans le liquide céphalorachidien, dans 5 autres cas, le germe responsable était le bacille pyocyanique et dans un cas il s'agissait du pneumocoque. Notre analyse n'a pas permis de découvrir avec certitude l'origine des accidents mais deux facteurs sont certainement à incriminer : (1) l'insuffisance du contrôle de la stérilisation des instruments et de l'asepsie, (2) presque toujours un état général très altéré du patient.

Les deux accidents que nous avons décrits sont compris dans cette série mais l'analyse de l'ensemble des accidents ne permet pas de retenir qu'ils sont directement liés à la modification de la technique classique.

Addendum

Depuis l'exposé oral de ce travail, vingt autres malades ont été examinés. Les suites ont été normales. Un contrôle rigoureux de la stérilisation et de l'asepsie a été observé. Dans tous les cas, une couverture d'antibiotiques a été administrée pendant les trois jours qui ont suivi l'examen.

RÉSUMÉ

La réinjection du liquide céphalo-rachidien soustrait en même temps que le retrait de l'air injecté évite le maintien du malade en position de Trendelenburg pendant les quarante-huit heures qui suivent une myélographie gazeuse sélective totale. Aussitôt après l'examen, le malade est allongé sans inconvénient en position horizontale.

SUMMARY

There is no need to keep the patient in the Trendelenburg position for 48 hours following total selective gaseous myelography if the cerebrospinal fluid is allowed to enter simultaneously with the escape of the air injected. The patient can be comfortably placed in horizontal position immediately after an examination performed in this manner.

ZUSAMMENFASSUNG

Es ist nicht notwendig den Patienten in der Trendelenburg Lage während den folgenden 48 Stunden nach totalselektiver Gasmyelographie zu behalten, wenn man gleichzeitig mit der Ausströmung der injizierten Luft die Zerebrospinalflüssigkeit hereinkommen lässt. Sofort eine in dieser Weise vorgenommene Untersuchung durchgeführt ist, kann der Patient in Horizontallage gebracht werden.

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DIAGNOSTIC RADIOLOGIQUE DES FORMES CONGENITALES, DES FORMES INTERMITTENTES ET DES FORMES PROGRESSIVES DE STENOSE DU CANAL RACHIDIEN AU NIVEAU DE L ATLAS

par

A WACKENHEIM

Il nous faut avant tout definir le terme de stenose car il implique a priori une notion de grandeur reduite des diametres Dans le present travail nous ne tiendrons compte que du diametre antero-posterieur puisqu il se prete mieux a l investigation radiologique Ce que nous appellerons stenose du canal sera en fait une stenose antero-posterieure

Diametre antero posterieur normal du canal osseux de l atlas Facile a mesurer sur une radiographie de profil ou mieux sur un tomogramme sagittal median ce diametre represente la plus petite distance qui separe la face posterieure de l odontoide de la face anterieure de l arc posterieur de l atlas. La valeur absolue de ce diametre est fort variable selon le developpement squelettique du sujet Une premiere constatation est toutefois fondamentale *la valeur absolue de ce diametre a p du canal atloidien est superieure à celle du diametre a p du canal axoidien* Cette difference ou ce gradient prend a notre avis la valeur d un critere de normalite

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Fig 2 Myelographie gazeuse cervicale Parties molles ligamentaires anterieures et posterieures



Fig 3 Augmentation du diamètre a p de l axis par l[illegible]on traumatique Pas de sténose de l atlas.

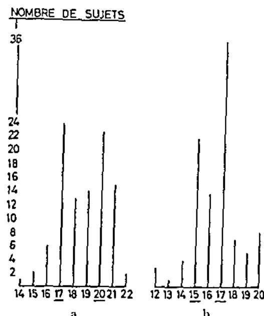


Fig 1 Diametre antero posterieur de l'atlas (a) et de l'axis (b) mesures chez cent sujets (apres correction de l'agrandissement radio graphique)

En mesurant les diametres a p de 100 sujets adultes normaux des deux sexes, nous avons trouve, apres correction de l'agrandissement radiographique, une dif ference individuelle de 0 a 5 *mm* L'ensemble du materiel fournit les chiffres *suivants, tous corriges d'apres l'agrandissement optique de l'image diametre* a p du canal au niveau de C1 14 a 22 mm, diametre a p du canal au niveau de C2 12 a 20 mm

Fig 1 illustre la repartition des 100 malades en differentes classes de diametres de sorte qu'il apparait clairement que le diametre moyen de l'atlas est de 17 a 20 mm alors que le diametre moyen de l'axis n'est que de 15 a 17 mm et que la difference individuelle est en moyenne de 2 a 3 mm

Diametre antero posterieur normal du canal intradural de l'atlas Notre ma teriel pneumographique est insuffisant pour que nous realisions la meme etude sur 100 malades Ce n'est que dans une trentaine de cas que les documents ont permis de verifier que les parties molles ligamentaires et durales avaient au niveau de l'atlas et de l'axis une epaisseur totale egale sur une section tomographique sagittale mediane (Fig 2) Si nous additionnons au niveau de l'atlas l'epaisseur des parties molles anterieures et posterieures, nous obtenons un chiffre sensible ment egal, a 1 mm pres, a celui de l'addition des memes parties molles anterieu res et posterieures au niveau de l'axis Il se trouve en effet que le systeme liga mento-dural est tres developpe en avant et tres peu developpe en arriere du niveau de C1 Au niveau de C2 par contre, le systeme ligamentaire est bien developpe en avant, mais egalement puissant en arriere La figure illustre cette

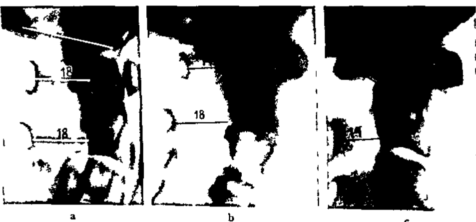


Fig. 4 a) Sténose a. p. relative de l'atlas. b) Nette sténose a. p. de l'atlas par dislocation odonto-atloïdienne rhumatismale. c) Forte sténose du canal de l'atlas par fracture de l'odontoïde.

facilement des sténoses absolues. Mais les perturbations radiologiques sont alors tellement importantes qu'il n'y a pas de doute sur la compression bulbo-cervicale et que la sténose du canal de l'atlas est évidente.

Sténose relative. Nous appelons sténose relative le fait que le diamètre a. p. de l'atlas est plus petit que celui de l'axis à condition qu'il ne s'agisse pas d'une augmentation du diamètre a. p. de l'axis comme dans la Fig. 3.

Canal intradural

Les mêmes principes président au diagnostic du caractère absolu ou relatif du canal intradural. Normalement le canal intradural a un diamètre a. p. légèrement plus grand au niveau de C1 que de C2. Les chiffres absolus de ces diamètres sont de 3 à 5 mm plus petits que ceux des diamètres osseux.

Le diagnostic radiologique des sténoses antéro-postérieures du canal rachidien osseux et intradural de l'atlas en pathologie

Les malformations de la charnière cervico-occipitale

Impression basilaire. Sur 21 cas d'impression basilaire de notre casuistique nous avons trouvé deux fois une sténose relative du canal osseux de l'atlas avec 18 mm pour C1 et pour C2 dans un cas et 16 mm pour C1 et pour C2 dans l'autre cas. La tendance est en matière d'impression basilaire plutôt à la dilata-

notion d'egalite de l'epaisseur totale anterieure et posterieure des parties molles ligamento durales au niveau de C1 et de C2 avec les chiffres absolus moyens suivants C1 2 a 4 mm (en avant) + 1 mm (en arriere) = 3 a 5 mm, C2 1 a 3 mm (en avant) + 2 mm (en arriere) = 3 a 5 mm

Cette constatation simple semble etre fondamentale car elle permet d'envisager la possibilite d'une stenose du canal intradural avec canal osseux normal Nous en avons rencontre un cas que nous rapportons ici

Criteres de normalite du diametre antero posterieur du canal rachidien au niveau de l'atlas Le canal osseux de l'atlas est normal lorsque son diametre antero posterieur se situe dans la marge de 14 a 22 mm Cette marge est trop grande pour prendre de la valeur en radiodiagnostic pratique

Le diametre antero-posterieur du canal osseux de l'atlas est normal lorsqu'il est superieur (ou egal?) au diametre antero-posterieur de l'axis Ce deuxieme critere nous parait être beaucoup plus utile en pratique Nous rapportons a ce propos le cas illustre dans Fig 3 La radiographie conventionnelle montre sans hesitation et sans demander de mesures que le diametre de l'atlas est plus petit que celui de l'axis Ceci est pour nous un signe radiologique tout a fait anormal, voire pathologique Or, dans le cas particulier il s'agissait non pas d'une stenose de l'atlas mais d'une dilatation du canal de l'axis par fracture Nous voulons demontrer par la que les valeurs absolues ont une faible importance mais que le gradient du diametre a p de C1 et C2 prend une importance de premier plan pour le radiodiagnostic

Les stenoses antero posterieures absolues et relatives du canal rachidien au niveau de l'atlas

Canal osseux

Stenoses absolues Rappelons d'abord que les travaux de BOIJSEN, de BURROWS, de HINCK, de NORDQVIST et d'ABOULKER sont consacres au diagnostic radiologique de stenoses absolues McRAE a pris position a la maniere d'un radiologiste en precisant que le diametre antero-posterieur du canal osseux de C1 devenait pathologique et responsable de deficits neurologiques lorsqu'il tombait en dessous de 19 mm Dans les cas de dislocation atlanto-axoidienne chronique, il signale des diametres a p de 8 a 20 mm

Dans notre material, la stenose peut etre appelee absolue, ce qui n'implique pas forcement son caractere pathogene, lorsque le diametre a p est inferieur a 14 mm Cette limite est purement statistique et ne tient compte ni du systeme ligamentodural ni des facteurs de correction indispensable d'ordre anthropometrique (taille, hauteur du tronc, etc) Des lesions traumatiques entrainent



Fig 6 Stenose relative de l atlas par hypoplasie atloidien ne





Fig. 7 Obstruction fonctionelle du trou de Magendie (pas d insufflation des ventricules par voie lombaire iodoventriculographie normale) Le diametre a p est de 15 mm au niveau de l atlas et de 16 mm au niveau de l axis

de l investigation radiographique (2) les stenoses relatives des syndromes algiques cervico-occipitaux (ils sont tres frequents Fig 6) et (3) les stenoses relatives de l atlas avec stenose des espaces sous-arachnoidiens de la charniere cervico-occipitale

Chez 4 malades nous avons constate une stenose relative avec bonne insufflation des ventricules. Les espaces sous-archnoidiens peribulbaire, valleculaire et de la grande citerne sont toutefois tres etroits. Les chiffres sont ainsi repartis dans les quatre cas

Cas No	*Canal osseux*		*Canal intradural*	
	C1	C2	C1	C2
1	*17*	*18*	?	?
2	*19*	*19*	14	13
3	*14*	*15*	*11*	*11*
4	*18*	*20*	*14*	*15*

Il existe donc dans les deux derniers cas (3 et 4) une stenose relative tant osseuse qu intradurale de l atlas.

Nous avons etudie par ailleurs 13 cas d obstruction fonctionelle du trou de Magendie c est a dire de malades qui n acceptent pas d air dans le systeme ventriculaire lors d insufflation par voie lombaire et ceci en l absence de toute anomalie apres controle ventriculographique Parmi ces treize cas huit sont porteurs d une stenose relative du canal osseux de l atlas (Fig 7) Les chiffres sont les suivants

Cas No	1	2	3	4	5	6	7	8
C1	15	16	17	14	18	15	14	14
C2	16	17	18	14	19	16	14	14



Fig. 5. Sténose intermittente apparaissant en flexion de la tête (dislocation odonto-atloïdienne chronique).

tion antéro-postérieure de l'atlas en raison de la fréquente association d'une malformation de Chiari.

Odontoïde mobile. Les données radiologiques sont ici superposables à celles des fractures de l'odontoïde, c'est-à-dire qu'il s'agit de sténoses intermittentes.

Manifestation de la vertèbre occipitale. Dans 17 cas de manifestation nous n'avons pas trouvé de sténose du canal osseux de l'atlas même lorsque la manifestation est importante.

Dislocation atloïdo-axoïdienne chronique de McRae. La définition même de cette malformation implique une diminution du diamètre a. p. de l'atlas en position de flexion de la tête (Fig. 5). Dans nos sept cas, nous trouvons

Cas No	1	2	3	4	5	6	7
C1	18	16	18	14	21	14	14
C2	18	17	21	16	18	15	14

Rétrécissement congénital du canal rachidien cervical. Sur 6 cas nous avons trouvé une seule fois une tendance à la sténose relative avec 16 mm pour C1 et pour C2.

Les sténoses relatives osseuses isolées

Dans notre très grand matériel radiologique, nous trouvons de cas de sténose relative de C1 sans autre malformation. Ces cas peuvent être divisés en trois catégories radio-cliniques : (1) les sténoses relatives asymptomatiques au moment



Fig 6 Stenose relative de l atlas par hypoplasie atloïdienne





Fig 7 Obstruction fonctionelle du trou de Magendie (pas d insufflation des ventricules par voie lombaire iodoventriculographie normale) Le diamètre a p est de 15 mm au niveau de l atlas et de 16 mm au niveau de l axis

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C1	15	16	17	14	18	15	14	14
C2	16	17	18	14	19	16	14	14



Fig. 8. Hypertrophie des ligaments de la paroi antérieure du canal atloïdien. Rétrécissement de l'opacité médullaire à ce niveau: quadriplégie progressive.

Le canal intradural n'a pas pu être suffisamment bien étudié dans tous ces cas. Tous sont caractérisés par l'impossibilité d'insuffler le système ventriculaire souvent après plusieurs tentatives séparées dans le temps. Nous pensons que la sténose relative de l'atlas est chez ces malades le témoin d'une malformation du cône occipito-cervical qui est à l'origine du trouble fonctionnel de la circulation de l'air au niveau du trou de Magendie.

Les sténoses relatives intermittentes

Toutes les mobilités anormales de l'odontoïde par fracture ou par élongation du ligament transverse rentrent dans cette catégorie de sténose. Leur étude radiologique nécessite une épreuve tomographique de flexion extension. En flexion de la tête, on peut observer des diminutions du diamètre a. p. de l'atlas de 3 à 5 mm (Fig. 4 et Fig. 5).

Les sténoses relatives progressives

Diverses ostéopathies chroniques peuvent aboutir à une sténose du canal de l'atlas. Nous avons observé trois cas rhumatologiques (polyarthrite rhumatoïde et spondylarthrite ankylosante).

Cas No	1	2	3
C1	16	14	15
C2 (voir Fig. 4)	17	18	15

Les stenoses relatives et primitives du canal intradural avec canal osseux normal

Nous n avons observe qu un seul cas de stenose antero-posterieure par epaississement de l appareil ligamentaire Le malade presentait une quadriplegie progressive d origine inconnue Nous admettons qu elle est en rapport avec l hyperplasie ligamentaire car il existe au meme niveau une atrophie localisee du cordon medullaire (Fig 8) Les chiffres sont les suivants

	Canal osseux	*Canal intradural*
C1	18	10
C2	16	10

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RÉSUMÉ

L auteur definit d abord les notions de sténose absolue et relative du canal atloidien dans son diametre antero-posterieur Il insiste ensuite sur la notion de stenose du canal par hyperplasie des ligaments Un rappel des grands cadres nosographiques dans lesquels s in scrivent les stenoses de l atlas permet d entrevoir la relative frequence de cette anomalie dont le veritable caractere pathogene ne peut etre envisage qu a l aide d une myelographie cervico-occipitale Bon nombre d obstructions fonctionnelles du trou de Magendie (non insufflation des cavites ventriculaires par voie lombaire) sont en rapport avec une stenose relative ou absolue de l atlas

SUMMARY

The concepts of absolute and relative stenosis of the vertebral canal at the level of the atlas based on its a p diameter are defined. It is affirmed that stenosis of the canal may be caused by hyperplasia of the ligaments The relative frequency of this anomaly is evident by considering the large range of general disease that includes stenosis of the canal of the atlas Its true pathogenic nature can be elucidated only by means of cervico-occipital myelography A number of functional obstructions of the foramen of Magendie (lumbar encephalography failing to demonstrate the ventricular system) are consistent with absolute or relative stenosis of the canal of the atlas

ZUSAMMENFASSUNG

Zuerst wird der Begriff der absoluten und relativen Atlas Stenose bestimmt Der Verfasser betont besonders die Stenose durch Hyperplasie der Bander Nachdem die verschiedenen Krankheitsbilder mit eventueller Atlas-Stenose aufgezahlt sind, wird an den besonderen Wert der Cam myelographie erinnert Funktionelle Obstruktion des Foramen magnum bei Encephalographie kann auf relative Atlas-Stenose zuruckgefuhrt werden



Fig. 8. Hypertrophie des ligaments de la paroi antérieure du canal atloïdien. Rétrécissement de l'opacité médullaire à ce niveau : quadriplégie progressive.

Le canal intradural n'a pas pu être suffisamment bien étudié dans tous ces cas. Tous sont caractérisés par l'impossibilité d'insuffler le système ventriculaire souvent après plusieurs tentatives séparées dans le temps. Nous pensons que la sténose relative de l'atlas est chez ces malades le témoin d'une malformation du *cône occipito-cervical qui est à l'origine du trouble fonctionnel de la circulation* de l'air au niveau du trou de Magendie.

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